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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1496

Washington, D. C. ▼ February, 1928

TIMBER GROWING AND LOGGING PRACTICE IN THE LAKE STATES

MEASURES NECESSARY TO KEEP FOREST LAND PRODUCTIVE AND TO PRODUCE FULL TIMBER CROPS

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By

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Introduction by

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By RAPHAEL ZON
Director, Lake States Forest Experiment Station

Introduction by W. B. GREELEY, *Forester, Forest Service*

INTRODUCTION

Forestry in the United States is no longer a theory, a subject for discussion, or a practice limited to public lands. It has gotten down to concrete things in the woods. The growing of timber is making headway in practical measures for protecting forest growth from fires, in logging timber so as to produce a new crop, and in planting forest trees on denuded areas. Timber values and other economic considerations are causing landowners more and more widely to study the possibilities of reforestation. There is a general demand for information on how to grow timber and on what timber growing will cost.

Timber culture in this country, like the growing of farm crops, is governed necessarily by our own soil and climate, by the requirements of our forest trees, and by our own economic circumstances. Lessons may be drawn from the experience of other countries; but profitable methods adapted to the wide range of forest and economic conditions in the United States can be developed only from our own experience and investigation.

The Forest Service is bringing together the results of this experience and investigation in a series of publications dealing with the 12 principal forest regions of the United States. The information has been gathered from many different sources, including the experience of landowners who are practicing forestry; and the results have been verified as far as possible by consultation with forest industries, State foresters, and forest schools. These publications thus undertake to set forth, in a simple form, what are believed to be the soundest methods of reforestation yet developed in the common experience and study of the United States.

No finality is claimed for the measures proposed. Forestry in every country has been a gradual evolution in industrial methods and woods practices. Much is yet to be learned about growing

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timber under American conditions. Our forestry practice will become more successful and profitable as new facts are applied, just as American agriculture and nearly every manufacturing process have been perfected through experience and research. But we know enough now to go right ahead. Believing that forest-land owners in the United States are ready now to engage in timber growing on a large scale, the Forest Service has endeavored to place before them in concise terms the best guides which the experience of this country to date affords.

The measures advocated in the forest region of the northern Lake States fall into two general groups. Mr. Zon starts off with the first steps—the least that must be done—to prevent timberland from becoming barren. These will seldom satisfy the landowner who goes in for real timber culture, but they may prevent his property from becoming a liability on his own hands and on the community.

The first steps in forestry proposed by Zon for the various sorts of woodland are extremely simple. They boil down very largely (1) to fireproofing the woods, within reason, by slash burning or other ways of controlling the slash hazard; and (2) to keeping fire out of the woods thereafter by a protective organization. There are some additional suggestions as to leaving seed trees or following simple cutting rules in certain types of forest.

These minimum requirements will bring back some sort of reasonably valuable forest growth on all of the land where timber remains to be cut. They can readily be carried out by the landowner. They are being followed now in a considerable number of cases. Their low cost and their soundness as a matter of business can scarcely be questioned.

On the other hand, considering the land problems of the Lake States and the common interest in keeping their wooded areas productive, these first steps in forestry represent about the least that the public can reasonably require of the landowner. If the owner is not prepared to do this much for the future of the land whose valuable products he is harvesting he may find more drastic measures imposed upon him by the public exercise of police power. The Forest Service believes that as a matter both of public welfare and of commercial returns from reforestation, these minimum requirements should be followed from now on in cutting the forests of northern Michigan, Wisconsin, and Minnesota.

The importance of protecting from fire the timberland and the cutover lands of the Lake States stands out very prominently in Zon's report. For this indispensable of forestry the public must assume a large measure of responsibility. The cooperative plan of forest protection embodied in the Clarke-McNary Act, under which costs are shared by the Federal Government, the State, and the landowner, is under way in this region but needs material strengthening and extension. This is primarily the task of the public agencies, State and Federal. However, as Zon points out, the individual owner can effectively supplement the protection system of the region by a small outlay on his own land; and there is little reason for him to wait until the general protection organization is 100 per cent complete before beginning to practice forestry. Numbers of landowners in the Lake States are striking out for themselves in forest protection

and showing what can be done once they are "sold" on growing timber.

The second group of measures proposed constitute what may be called desirable forestry practice. They are designed to grow crops of the more valuable products and to use fully the productive capacity of the land. The recommendations embodied in this group of measures are addressed primarily to the landowner who wishes to get the most out of his property in real timber culture.

It is impossible to formulate a set of measures of this character that would be adapted to the great variety of growth types and of industrial requirements found in the Lake States. Hence, Zon has simply outlined the more fundamental things, with illustrative methods of forest practice. The details of forestry, like the details of engineering, require expert study to determine the plans and methods adapted to a particular tract of land or a particular business. One of the most important features of forest planning is to devise not simply woods operations that will produce the most valuable crops of timber, but a program of land ownership and logging that will furnish a continuous yield of the products desired or a sustained supply of raw material for plant requirements.

The opportunity afforded by such a program for a continuous inflow of timber is usually the soundest business or financial approach to forestry. To the extent that this continuous inflow of timber can be attained, stability is built into the entire structure of a wood-using industry. Plant investments, credit, merchandizing plans, and opportunities to develop by-products can often be recast on more secure and advantageous lines once this policy of raw-material supply is settled. Forestry often involves much more than what to do with a piece of land. It may be the key to the most fundamental features of a business.

From this viewpoint, Zon's common-sense presentation of the financial aspects of holding land for timber growth is particularly commendable. In the last 50 years American wood-using industries of many kinds have become accustomed to holding timber reserves behind their plants. They pay carrying charges on these reserve supplies—often for 20 or 30 years—as a matter of course in order to protect their plant investments and hold their trade. It is but a slight modification of the same principle to carry a reserve, not in the form of costly old-growth stumpage, but of growing forests sufficient in extent to mature from year to year the volume of wood required for manufacture.

There are decided financial possibilities in this new form of timber reserve. A tract of virgin timber seldom improves in either quality or volume while it is being carried. It may deteriorate in one or both. Its value ordinarily becomes greater only as the stumpage prices of the region advance. But a tract of growing forest, if well protected, is attaining higher quality and greater volume every year. And it has the same opportunity as a virgin stand to share in a general enhancement of timber values. Broadly speaking, a growing forest has three chances to earn profit while a forest of old growth has but one. And the cost of carrying it, figured per thousand feet or per cord coming to the mill, may be less than the cost of an old-growth reserve when it reaches the manufacturing plant.

No rule of thumb can be written that would cover the many elements and risks entering into such a calculation. But it is worthy of note that forestry offers a fresh opportunity for applying the same principle of carrying timber reserves that has long been followed by the more stable and well-organized units among wood-using industries.

It is not practicable to draw a hard-and-fast line between the first steps that will maintain some degree of productiveness on forest land and the more intensive measures that will bring the quantity and quality of wood produced more nearly up to ideal results. Zon has not attempted, therefore, to deal with two general types of forest practice as separate and distinct. He has rather presented a common-sense résumé of various steps in timber growing in a form that will be most helpful to the man in the woods. His bulletin has been written primarily for the landowner and the lumberman, to whom timber growing is a concrete business and logging problem.

To the men who own forest-producing land in the Lake States or who are engaged in industries which require timber as raw material, forestry now offers a commercial opportunity. Satisfactory returns from forestry can not be promised in sweeping terms any more than returns from the manufacture of lumber or paper. But the opportunity for a profitable employment of capital and business talent in the growing of timber merits the same consideration and the same expert study as industrial opportunities in the manufacture of timber. This applies with special force to commercial institutions which have made large capital investments in manufacturing plants and distributing organizations, dependent for their maintenance upon a future supply of forest-grown materials. But it applies no less to owners of land, in large tracts or farm wood lots, the earning capacity of which lies in the growing of trees and which, without tree growth, will become either a doubtful asset or an outright liability.

The Forest Service earnestly asks the forest-land owners of the Lake States to determine for themselves, with the same care with which they would approach any other business problem, whether timber growing offers a commercial opportunity which they should grasp. It commends this publication to them, not as a complete or authoritative scheme that can forthwith be followed with profit in their own woods, but as a starting point in utilizing the opportunities that forestry may hold out to them.

The Forest Service has tremendous faith in the commercial promise of timber growing to American landowners. The law of supply and demand is working steadily to create timber values in the Lake States which will pay fair returns on forestry as a business. The economic history of other countries which have passed through a cycle of virgin forest depletion like our own, points to the same conclusion. The time is approaching when forestry, and forestry alone, will supply the enormous quantities of wood demanded by American markets. The fundamental laws of business must in the nature of things so operate as to enable the markets for forest products to be supplied at a profit to the grower of timber. The returns already secured from forestry at points in the eastern United States show that this relationship between the value of timber and the cost of producing it is coming about.

W. B. Greeley.

THE CRUX OF THE FOREST PROBLEM IN THE LAKE STATES

Two significant facts with regard to forests and forest lands in Michigan, Wisconsin, and Minnesota stand out clearly. First, that the area of the remaining old merchantable timber in the Lake States is small (17.7 per cent of the total forest land), as compared with the large area of oncoming second growth (46.4 per cent) and the vast area of nonrestocking and unproductive cut-over land (35.9 per cent); second, that most of the forest land (95 per cent) is owned by private individuals and corporations. (Tables 1 and 2.) These facts force the conclusion that if the forest problem in the Lake States is to be solved, it must be worked out on the lands now in private ownership and must deal largely with second-growth timber and nonrestocking cut-over land.

The large area of low-grade soils of little or no prospective value for agriculture; the very slow absorption into agriculture of the stump lands of a character undoubtedly suitable for agriculture; the accumulating taxes on unproductive stump lands; the increasing financial difficulties of the communities located in areas where the forest industries are failing for lack of raw material; the rising prices for saw timber and pulpwood—all these combine to force a new and sober consideration of the cut-over lands and their future. What should be done with them is worrying many a forest-land-owner, and he is beginning to inquire more and more into the possibility of timber growing on his land as the best practicable solution.

TABLE 1.—*Character of forest land in the Lake States* [1]

(In thousand acres—i. e., 000 omitted)

State	Old merchantable	Second growth		Nonrestocking	Total forest area
		Merchantable	Nonmerchantable		
Wisconsin	2,100	3,800	5,100	6,800	17,800
Michigan	4,500	3,500	3,300	7,100	18,400
Minnesota	3,500	6,600	4,200	6,600	20,900
Total	10,100	13,900	12,600	20,500	57,100
Per cent of total	17.7	24.3	22.1	35.9	100

[1] TIMBER DEPLETION, LUMBER PRICES, LUMBER EXPORTS, AND CONCENTRATION OF TIMBER OWNERSHIP. Forest Service, U. S. Dept. Agr. Report on Senate Resolution 311. 1920.

TABLE 2.—*Ownership of forest land in the Lake States* [1]

(In thousand acres—i. e., 000 omitted)

State	Federal [2]	State	Private		Total
			Wood lots	Large forests	
Wisconsin		300	5,400	12,100	17,800
Michigan	127	648	3,897	13,728	18,400
Minnesota	991	736	4,500	14,673	20,900
Total	1,118	1,684	13,797	40,501	57,100
Per cent of total	2.0	2.9	24.2	70.9	100

[1] From U. S. Dept. of Agr. Yearbook, 1922. [2] Net areas as of June 30, 1925.

THE NORTHERN CONIFER–HARDWOOD FORESTS

The forests of the Lake States fall roughly into two parts: The northern conifer–hardwoods region and the southern oak–hickory region. The line of division extends from Saginaw Bay on Lake Huron in a somewhat southwesterly direction across Michigan to Grand Haven on the eastern shore of Lake Michigan; then from Sheboygan in a northwesterly direction across Wisconsin to St. Croix Falls; thence across Minnesota, again in a northwesterly direction, to Wadena; thence north to Thief River Falls and the Canadian boundary. (Fig. 1.) It is with the northern conifer–hardwoods that this bulletin is concerned. The oak–hickory forest is a part of the central hardwood region, the problems of which are discussed in a separate bulletin.[1]

A REGION OF EXTENSIVE COMMERCIAL FORESTS

The northern conifer–hardwood region embraces the northern portion of Michigan, Wisconsin, and Minnesota. It is a region of innumerable lakes and coniferous swamp forests, large and small, jack-pine plains, aspen–birch second growth, and the characteristic northern hardwoods, birch, beech, and maple, mixed with hemlock. The forest lands of the region, which probably amount to about two-thirds of the total land area, present the greatest field for commercial forestry in the Lake States. It is here particularly that proper methods must be applied in order to utilize vast areas of cut-over lands and to grow timber to support the sawmills and the pulp-and-paper industry.

Four broad classes of forest lands may be recognized: (1) Northern hardwoods and hemlock, (2) pine, (3) aspen–birch, and (4) forested swamps. The comparative extent of these is roughly estimated in Table 3.

TABLE 3.—*Areas of principal forest types in the northern conifer–hardwood region of the Lake States*

Type	Area	
	Million acres	*Per cent*
Northern hardwoods	7.0	16.5
White and red pine	0.5	1.2
Jack pine (including scrub oak)	9.0	21.1
Aspen–birch	21.0	49.4
Forested swamp	5.0	11.8
Total	42.5	100.0

NORTHERN HARDWOODS

In the Upper Peninsula of Michigan, the northwestern part of the lower peninsula, and the northeastern part of Wisconsin, the hardwoods are typically sugar maple (*Acer saccharum*), yellow birch (*Betula lutea*), basswood (*Tilia glabra*), and beech (*Fagus grandifolia*), with admixture of eastern hemlock (*Tsuga canadensis*),

[1] TILLOTSON, C. R. TIMBER GROWING AND LOGGING PRACTICE IN THE CENTRAL HARDWOOD REGION. U. S. Dept. Agr., Dept. Bul. 1491, 39 p. illus. 1927.

although the abundance of beech and hemlock varies greatly. In western Wisconsin, and especially in Minnesota, the character of the forest is modified, and sugar maple and basswood with a little elm (*Ulmus americana*) and yellow birch make up the type. What is known in western Wisconsin and Minnesota as the hardwood type is largely aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*), which have come up after fires.

Northern white pine once attained its best development within this type, the evidence of this taking the form of scattered, big trees, doubtless remnants of a much denser stand of white pine which was gradually crowded out by incoming hardwoods. Most of the white pine has now been removed from these hardwood stands. The hardwood forest is on fair to good agricultural land, much of which, were there a demand for it, might be cleared, settled, and farmed.

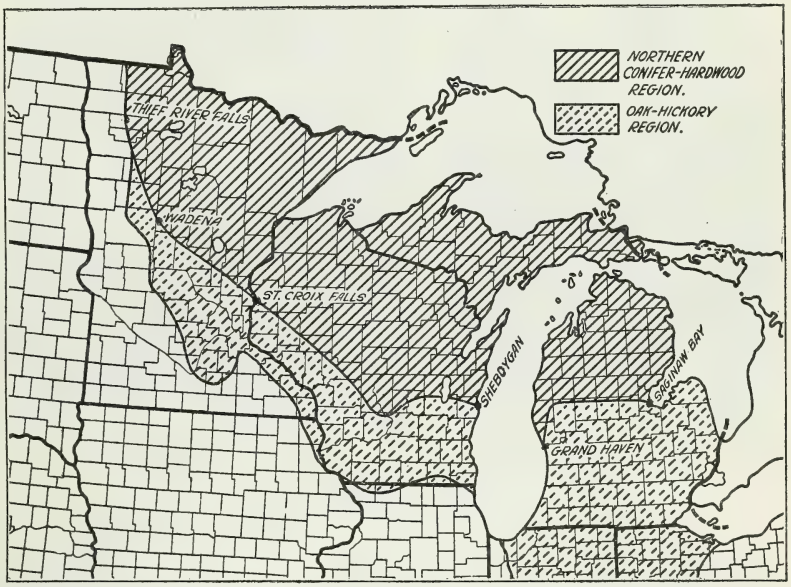


FIG. 1.—The northern conifer-hardwood and the oak-hickory regions of the Lake States

PINELANDS

The present pinelands vary from barrens, which contain little but grass, sweet fern, blueberry, and willow bushes, and scrubby jack pine (*Pinus banksiana*), through typical jack-pine lands to excellent stands of Norway pine (*P. resinosa*) and northern white pine (*P. strobus*), as found on the Minnesota National Forest.

The two types that need be considered are Norway and white pine and jack pine.

NORWAY AND WHITE PINE

These two pines, as a rule, intermingle. On better lands white pine predominates; on the lighter soils, Norway pine. Originally white pine occurred as a distinct forest, chiefly in the central part of Michigan and Wisconsin and the east-central part of Minnesota

on moderately fresh sandy or loamy soils. Where it is still found, white pine grows either in pure second-growth stands or as occasional trees in the forests of Norway pine or hardwoods.

Norway pine forests originally occupied sandy soils, drier as a rule than those occupied by the white pine, in central Michigan, Wisconsin, and Minnesota, and northward. Not many of these Norway pine forests now remain in the Lake States, but where they are still found Norway pine grows either pure or forms the principal tree in mixture with jack or white pine and also occasionally with hemlock or oaks. The bulk of the remaining Norway pine timber is on national-forest land, on State land such as Itasca Park, or on Indian reservations around Red Lake, Minn. In Wisconsin and Michigan practically none of it is left. There are, however, small and scattered tracts privately owned.

JACK PINE

The jack-pine forest is now typical of central Michigan, Wisconsin, and west-central Minnesota, northward. It tends to occupy the driest, sandiest soils. In this region it occurs either pure or as the principal tree in mixture with Norway pine or with scarlet or jack oaks (*Quercus coccinea* and *Q. ellipsoidalis*), or sometimes in patches with aspen and paper birch in northeastern Minnesota.

In the most northeastern portions of Minnesota are large stretches of jack pine on thin, rocky, but fertile soils. The land, originally occupied by white pine and spruce was taken over by jack pine as a result of severe fires, which occurred 60 or 70 years ago. In the older jack-pine stands there is a fairly dense undergrowth of black and white spruce (*Picea mariana* and *P. glauca*), balsam fir (*Abies balsamea*), and white pine. In the younger jack-pine stands there is some paper birch, aspen, and only a scattering of spruce and balsam reproduction. Occasionally throughout these jack-pine stands one still finds a large white pine, a remnant of the original forest.

ASPEN–PAPER BIRCH

The aspen–paper birch forest is most common in northern Minnesota, Wisconsin, and Michigan, on well-drained upland soils. As a rule it follows fires on white pine or hardwood lands and is made up in the earliest stage of aspen, pure or in mixture, and paper birch in varying proportions, the birch predominating occasionally over small areas. As the stand grows older, white pine, balsam fir, and spruce often become conspicuous under the shade of the aspen and birch and may eventually replace them.

Different stages in the development of the aspen–paper birch type may be found throughout the northern conifer–hardwoods region, ranging from pure stands occupying extensive areas to mixed stands in which even jack pine has a place. The aspen found in pure stands is practically even-aged. In many stands of aspen 50 or 60 years old one can still find, charred by old fires, large white-pine stumps, snags, and logs, which clearly point to the origin of the aspen after cutting of white pine followed by burning. Some pure stands of aspen in Minnesota are about 80 years old, but the average age is nearer 20 years. Few old stands, moreover, contain more timber than at 60 years, for after 60 years aspen usually deteriorates from disease.

EFFECTS OF LOGGING AND FIRES

A. A splendid second growth of hardwoods on land in the lower peninsula of Michigan cut clean but not burned

B. A mixed forest of spruce, balsam fir, and paper birch that has come in as the result of fires without cutting on white pine land in northern Minnesota. (F–173074)

C. Jack pine coming in following clear cutting of Norway pine and fires in the lower peninsula of Michigan

ASPEN AND PAPER BIRCH ON WHITE PINE LAND IN NORTHERN MINNESOTA

A. Paper birch that sprang up following a clear cutting and burning
B. Aspen taking possession after clean cutting and fire
C. Under this aspen stand that followed clean cutting, young spruce and white pine are already coming in. (F–25498–A)

The area of the aspen type in the northern parts of the Lake States is extensive and for the last 30 years has been on the increase as a result of fires in the better white-pine and hardwood lands. Most of this land cut over in Minnesota, Wisconsin, and Michigan has been badly burned and now carries only a scrubby growth of aspen and paper birch. In a study in St. Louis County, Minn., the Cloquet Forest Experiment Station [2] found 70 per cent of the cut-over lands occupied by these species, including stands where aspen and birch are mixed with balsam, spruce, or pine. This type of tree growth undoubtedly covers more area than any other one type in Wisconsin and Minnesota.

SWAMP FORESTS

About 25 per cent of the conifer–hardwood region is classed as swamp land. Not all of this swamp land is forest land. Much of it is bog which bears no forest, or forest of such poor development that it can not be classed with productive forest land. There may be recognized four types of swamp forests:

NORTHERN WHITE CEDAR SWAMPS

These are typical of the northern portions of the region. Cedar (*Thuja occidentalis*) occurs pure or in mixture with balsam fir, paper birch, tamarack (*Larix laricina*), spruce, black ash (*Fraxinus nigra*), red maple (*Acer rubrum*), and balsam poplar or balm-of-Gilead (*Populus balsamifera*). It develops best in swamps with fair drainage.

TAMARACK SWAMPS

These are found throughout the region. Tamarack grows either pure or in mixture with black spruce, also with some cedar, spruce, and fir. It develops in poorly drained acid swamps or bogs.

BLACK SPRUCE SWAMPS

These are typical of central Michigan, Wisconsin, and Minnesota, and northward. Black spruce occurs either pure or with a little tamarack, usually in acid and undrained bogs.

MIXED SWAMP FOREST

This is made up of red maple, black ash, balsam poplar, balsam fir, cedar, tamarack, spruce, and white pine, and occurs on the better-drained swamps bordering upland. It comprises species that occur both on the uplands and in the swamps, and for this reason may be considered as a transition type between the typical swamp forest and the upland forest.

Distinctions between cedar swamp, tamarack swamp, and spruce swamp are based on the predominance of one of the three species, all of which usually are present. This predominance is associated

[2] HANSEN, T. S. SECOND GROWTH ON CUT-OVER LANDS IN ST. LOUIS COUNTY. Univ. Minn. Agri. Exp. Sta. Bul. 203. 1923.

with the drainage conditions, and somewhat with the depth and character of peat on which the forest grows. Tamarack swamps are usually found on the least-drained lowland in which the peat is 3 or more feet in depth. Where the peat is between 2 and 3 feet deep and is better drained there is a greater admixture of spruce and cedar. Where it is shallow, from 1 to 2 feet, and the drainage is good, the swamp assumes the mixed composition of the transition type—the most valuable type of all swamp forests. Occasionally, the peat is 10 to 20 feet thick and yet the swamp is fairly well drained; under such conditions all swamp species grow well. Apparently it is not the depth of the peat that affects the growth but the poor drainage conditions which usually are found in the heavier peat swamps.

The present merchantable black-spruce forests are more than 100 years old and over large areas do not average more than 8 to 12 cords to the acre. They are made up of trees of various diameters if not of different ages. Trees 3 inches through are often 70 to 80 years old, and may be 150 to 200 years old. Many spruce stands in the swamps have the appearance of young reproduction but upon examination prove to be made up of old trees. Reproduction in the spruce swamps is rarely dense. On poor sites it rarely exceeds 1,000 to 1,500 young trees per acre.

It takes swamp white cedar from 10 to 20 years to grow 1 inch in diameter. Cedar produces 6-inch posts in 60 to 90 years and ties in 150 to 175 years; poles are not produced in less than 175 to 200 years. Tamarack in swamps may produce ties in 100 to 120 years.

On the drier and warmer sites, white cedar may grow 10 inches in 100 years and tamarack 8 to 10 inches in 40 years. Even black spruce can be grown on the better and drier sites in 50 to 60 years for pulp, and will average about 6 inches in diameter. Balsam fir does even better than spruce on the better sites. White cedar on dry or well-drained soils grows almost twice as fast as in the swamps. On loamy soils cedar has been found to grow 6 inches in 39 years. The poor growth in swamps is, therefore, not inherent in the species themselves but is due to the conditions under which they grow.

WHAT LOGGING AND FIRES DO TO THE FOREST

Any conclusion as to the measures needed to keep the forests of the region productive must be based upon a clear understanding of the effects which fires and present methods of logging have upon second growth. These effects vary in different kinds of forests. An analysis of what happens to second growth as a result of cutting or of cutting and fires must, therefore, be made for each type of forest separately.

EFFECT OF LOGGING AND FIRES UPON HARDWOOD–HEMLOCK FORESTS

The hardwood forests of birch, beech, and maple are almost entirely in private ownership, and at present are cut for all the merchantable timber there is in them. Merchantability, however, varies considerably from place to place. In certain districts, for instance, cordwood from the tops and defective logs can be disposed of for

distillation ("chemical wood"), whereas in other districts such material can not be handled profitably and is left in the woods. However the stand has been cut, the slash is as a rule left as it happens to lie when logging is finished, and even when the cordwood has been taken out a great tangle of drying débris remains on the ground. With few and rather minor exceptions, this slash presently burns. Whereas many slash fires are accidental, some are deliberately set by the owners of the land, or by neighboring settlers, with the idea of clearing the land for agriculture, or for other reasons.

The first hardwood slash fires usually generate much and prolonged heat and not only consume most of the logging débris but along with it the occasional defective or otherwise unmerchantable seed trees which may have been left standing, and the seedlings. In many instances a second tangle develops within a few years, this time consisting of blackberry or raspberry bushes and more or less tree growth. A second fire is now to be expected, and although it is not so hot as the first fire as a rule, it leaves very little of the original species save an occasional basswood sprout, and the land is now in typical "cut-over" condition.

The first tree growth which comes in following clean cutting and slash fires is usually aspen, pin cherry (*Prunus pennsylvanica*), paper birch, and a few scattering trees of basswood, maple, and elm—trees similar to those which formed the original stand. The proportion of the species of the original stand present in hardwood second growth is usually dependent upon the severity of the fires. If the fires happened to be light, much maple, elm, and basswood will be mixed with the aspen, paper birch, and pin cherry.

Where hardwoods have been cut clean and the slash has not been burned, with few exceptions, the land is immediately taken by a new and thrifty hardwood growth originating from the stump, from seedlings left after logging, or from the germination of tree seed in the ground, and supplemented by new seed blown in from neighboring uncut timber or from the scattering mature trees left because of defect. The mixture of tree species in second-growth hardwoods which have come in following logging, but without fire, is usually very similar to that in the original stand but, as a rule, with less beech and little or no hemlock. The presence of the old tops and débris of logging, as the old slash rots away, does not seriously impede the development of such second-growth hardwood. It undoubtedly assists the new forest by developing a mulch of rotten wood and by liberating food substances for the tree roots. (Pl. 1, A.)

In instances where only a few of the largest or most valuable trees have been taken out during the first cutting, or where windfall has opened the original stand as if by partial cutting, the openings are nearly always filled at once by young growth more closely similar to the neighboring old growth than that following clean cutting. It is quite certain, therefore, that partial cutting of mature hardwood, when not followed by fire, will result in the prompt development of new growth very like the original stand.

Hemlock remaining after a severe or clean cutting of the hardwoods dies out rapidly, evidently as the result of exposure to light and drying. Hemlock is also very susceptible to damage by fire, so that even a single light fire may practically eliminate the hemlock

from a second-growth stand, even though much of the young hardwood is left. It seems evident, therefore, that to insure hemlock second growth, only light cutting in the original stand can be considered, and that fire protection must be complete.

CLEAR CUTTING AND FIRES CHANGE NORWAY AND WHITE PINE FORESTS INTO JACK PINE OR ASPEN FORESTS

In the past Norway or white pine forests have been cut clean, and the slashings as a rule have caught fire. Pure stands of old growth in the Lake States are now almost entirely lacking. There are, however, many areas which show what has happened. When the pine was cut clean and the ground burned, the second growth that came up was, on the better or white-pine soils, either pure aspen or a mixture of aspen, paper birch, and red maple, and on the sandier or Norway pine soils, jack pine and oak. (Pl. 1, C.) This is very similar to the second growth that comes in on hardwood land cut clean and repeatedly burned, except that on the white-pine land this effect is obtained more quickly, after one or possibly two fires, whereas it may take several more burnings on the hardwood land to produce like results. If the land was burned only once, there is, as a rule, a fair scattering of pine in the new stand.

The general result is the predominance of jack pine in the second growth, and where the fires were repeated and particularly severe even the jack pine has been cleaned out and is succeeded, in Wisconsin and Michigan, by scrub oak and red maple; or, finally, the land has sometimes become entirely barren of tree growth.

CLEAR CUTTING AND BURNING JACK-PINE FOREST BEGETS JACK PINE

In the Lake States there are from 8,000,000 to 10,000,000 acres of jack-pine land, a considerable portion of which has been won by the jack pine at the expense of the original Norway and white pine, especially the former. Until a few years ago jack pine was not cut to any extent. At present, however, the cutting of jack pine is increasing rapidly. When jack pine is cut clean and the ground is burned, jack pine follows, except that the quality of the stand becomes poorer with repeated burning. Where scarlet and other oaks are present, as in the Lower Peninsula of Michigan, these tend to increase with successive fires, and ultimately the whole stand becomes unmerchantable scrub or gives way to sweet fern and blueberry barrens. If several fires follow at short intervals before the jack pine has reached seeding age the pine is eliminated in a very short time and the ground is then occupied by brush and an irregular sod of berry plants, grass, sedge, lichens, and moss.

When jack pine on sandy soils is cut clean and the ground is not burned or is only lightly burned, jack-pine reproduction will usually follow. In partial cutting of jack pine on sandy soils—a method that is now being used on the Minnesota National Forest, where the timber is cut for ties or box boards—jack pine second growth is assured; and if, in addition, seed trees of Norway pine are close by there may be a sprinkling of Norway-pine reproduction. Under such

conditions partial cutting of jack pine, when not followed by fire, may increase the proportion of Norway pine in the second growth.

When the jack pine on the thin, rocky soil in northeastern Minnesota, as exemplified in the Superior National Forest and surrounding country, is cut clean and the slashings burned, the second growth will usually be jack pine. When jack pine is not cut clean, or even when it is cut clean but the slashings are not burned, the second growth is apt to be a mixture of white pine, white and black spruce, balsam fir, aspen, and birch, with little or no jack pine. The soil of the out-crop region, although thin, is fertile and is a great battle ground or tension zone for the occupancy of which several species are contending. Only fires or clear cutting followed by fires can turn over the ground to the sole possession of jack pine unmixed with white pine, birch, and aspen. The soil naturally is more adapted to white pine and spruce than to jack pine, as is clearly indicated by the remnant of the original forest which existed in this region before the severe fires of over half a century ago. (Pl. 1 B.)

In the natural course of development without interference by man the jack-pine stands on the thin but fertile soils of northeastern Minnesota are gradually reverting to white pine and spruce. In the older jack-pine stands, even down to 60 years, white pine and spruce are slowly replacing the jack pine. Different stages in this process may be found throughout the region, from pure jack-pine stands with only a smattering of small white pine and spruce to mixed stands of jack pine, white pine, spruce, and balsam fir, almost of the same size and height. Fires and even burning of slashings in this region, besides favoring jack pine, are disastrous because of their effect on the thin soil. When fire has destroyed the soil and the rock is exposed the recovery of the land to forest, even to jack pine, is very slow and the resulting stands are inferior.

ASPEN AND PAPER BIRCH FOLLOW CLEAR CUTTING AND FIRES ON HARDWOOD OR WHITE PINE LAND

Aspen and birch stands, since as a rule they result from clear cutting and burning of the hardwoods or the white pine on the better soils, may be considered as a stage in the development of hardwood and white-pine forests. If the cut-over land is protected from fire, and if seed from conifers is available, some conifers may also be found in the growth of aspen and birch which will spring up. On the better-drained lands these will be white pine, and farther north, spruce and balsam fir; on the moister sites, spruce and cedar, or, in some instances, hardwoods such as maple and basswood. (Pl. 2, B and C.)

The commonly prevailing opinion that aspen and birch stands in the course of time invariably change into coniferous stands is not supported by actual facts. Aspen and birch stands may eventually be succeeded by spruce and pine, but only when these trees get a start on the cut-over land simultaneously with the aspen and birch. Whenever they are found in mixture with aspen and birch they prove to be practically the same age as the aspen, and thus to have started

at the same time. Once aspen stands are thoroughly established, the invasion of such conifers as white pine or spruce is exceedingly slow. The impression that the pine and spruce appear in the aspen stands as late comers is due to their slower growth when young. This makes them seem to have come up under the shade of the aspen. Balsam fir, however, does come into aspen and birch stands long after they are fully established.

The reason for the slowness of the conversion of aspen stands into conifers may be the lack of available seed supply, dense shade under the aspen, and the ravages of rabbits. Rabbits, in years when they are abundant, are particularly destructive to white pine, and less so to spruce and balsam fir. Whatever the cause may be, once aspen and birch take possession of the cut-over area, white pine and spruce get a foothold only with great difficulty. The conditions at the time of cutting or burning determine, therefore, to a large extent whether the aspen stands will in one generation be succeeded by conifers.

A survey of aspen stands throughout the region shows that not more than from 15 to 20 per cent of them have enough white pine or spruce to replace them in the course of 50 or 60 years when the aspen begins to deteriorate. Since aspen stands cover close to two-thirds or even three-fourths of the entire cut-over area of the original hardwood and white-pine forest, some 21,000,000 acres of aspen will remain for all practical purposes nothing but poor aspen–birch stands, succeeded here and there by balsam fir, unless converted with the aid of man into the more valuable forests of white pine and spruce.

SWAMP FORESTS LITTLE CHANGED BY LOGGING

There are some 9,000,000 acres of swamps and swamp forests in the Lake States region. A great deal of the swamp land is practically waste, since the growth in a typical swamp is not over one-sixth of a cord per acre per year and often is less. It is doubtful whether the swamp forests at their present rate of growth lend themselves to profitable forest management by private owners. Yet the swamp forests are the only extensive virgin forests remaining in this region, and they are the source of pulpwood, posts, and poles—material that is getting increasingly scarce.

The swamp forests are rarely cut clean, except when pure black spruce is cut for pulpwood, or when the land is drained and cleared for other use. If cutting is not followed by fire the original type will follow, except that where cedar was present in the old forest it will probably predominate in second growth. Cedar is the most aggressive in reproduction of all species found in northern swamps. It will often make up 75 to 90 per cent of reproduction. If cutting is followed by a light fire—that is, if the fire occurs when slash is fairly dry but the ground still moist—the same type will follow but with greater or less mixture of aspen, birch, red maple, black ash, balsam, poplar, and alder (*Alnus incana*). If, however, the peat is dry and the fire burns up the surface soil, the original type will reestablish itself only slowly, if at all, and alder, willows, and similar species will occupy the ground for indefinite periods.

FIRST AID TO REFORESTATION

Several roads are open to owners in the handling of their timberlands: (1) To dispose of the cut-over land to settlers; (2) to abandon the land and allow it to revert for nonpayment of taxes, to the State as in Michigan, to the county as in Wisconsin, or to the delinquent-tax list as in Minnesota; or (3) to devote the cut-over land to growing timber and to handle the remaining old timber in such a way as to leave the land in good productive condition.

About a decade ago most of the timber owners thought that the first road was the best. The plan, however, did not work. The sandy pine lands proved unsuitable for agriculture, and even the better hardwood lands could find but few settlers. With the agricultural area shrinking, there is little opportunity for many years to come to dispose of the cut-over lands to settlers for agricultural use. This has been forcibly driven home to many land companies in the region within the last few years. Few, however, wish to abandon the land altogether. In a mineralized belt there is always a possibility that iron in paying quantities may be discovered in the land. Some owners still hope that one of these days a "back-to-the-land" movement may start again or some other land boom as, for instance, by recreation seekers. Although much of the logged-off land goes on the delinquent-tax list, a general disinclination is evident, at least on the part of the larger owners, to abandon the land altogether. The third expedient of keeping the land and encouraging timber growth on it begins, therefore, to appeal to many owners as a reasonable solution of their land problem.

Even if the owner himself has no hope of utilizing the growth on the cut-over land, second growth in the Lake States, as already in the New England States, will have a sale value. Where bare land with no second growth on it has practically no market value for forest or recreation purposes, land covered with thrifty second growth has sufficient sale value to justify an expenditure for its protection. There is already a growing demand for second-growth jack pine if it can be found in sufficiently large and solid blocks.

Timber owners and operators largely misapprehend what timber growing means. To very many, reforestation or timber growing means planting trees. Forest planting over large areas by private owners is the last resort and presupposes a degree of forest management which has not yet been attained. Intensive forest practice in the Lake States will not come overnight. As a general rule, it will be a gradual process; first, some simple and crude kind of forestry; and later, as the owners gain more confidence in the new enterprise, more intensive methods will come into use.

The management of forest lands by private owners, even a simple kind of management, presupposes certain general conditions. The owner must be assured of tolerably good protection for his forest lands. He must have confidence that his investments in timber growing will not be impaired by unfair taxation. And he must have a certain accumulation of reliable facts regarding the possible yields from different kinds of forest land and the cost of forest

operations, so as to be able to forecast his returns. Before attempting, therefore, to outline specific measures for handling different forest types, the essential conditions for the practice of forestry and the broad principles involved will be discussed.

FIRE PREVENTION—THE KEY TO THE SITUATION

A study of the effect of cutting and fires upon second growth in the different forest types shows that the whole problem of handling timberlands in the Lake States, if the aim is merely to produce some kind of forest crop, simmers down to fire protection. All evidence unmistakably points to one thing, namely, that no matter how the present merchantable timber on private lands is cut, if fire protection is given from the start, or even after the area has been once burned over, the land will come back to forest growth of economic importance. (Pl. 2, A.) It will not always be like the forest that has been cut over, nor will it always contain trees of the more valuable species. After a single burning it will usually tend to aspen or jack pine, or, in northern Minnesota, aspen and paper birch. In the Upper Peninsula of Michigan the young growth will be maple, birch, and beech, with little or no hemlock; and on many of the sandy soils of the Lower Peninsula of Michigan, western Wisconsin, and central Minnesota it will be jack pine. These species are now of recognized commercial value, and they will be much more valuable in a few years.

Aspen, paper birch, and jack pine will be the redemption of northern Minnesota and the northern part of the Lower Peninsula of Michigan and will pave the way to real timber growing on a large scale in another generation.

Fire protection, therefore, is the most essential measure to keep forest land in a productive condition. Forest-fire protection, just like the protection of properties in cities and towns, is recognized as one of the important public functions of any organized community. Historic, political, and economic conditions will dictate the particular form of organization which the State is to adopt for providing forest-fire protection. There are, however, a few fundamental principles which must underlie any effective forest-fire protective organization.

GENERAL FIRE ORGANIZATION

The essential features of an effective fire-protection organization may be considered from three standpoints: (1) Organization, (2) effectiveness, and (3) financial responsibility.

ORGANIZATION

Experience shows conclusively that any protective organization should consist of a nucleus of permanent men, an additional force employed full time during the fire season, and an emergency organization.

The permanent force should consist partly of the administrative and supervisory unit at the headquarters and partly of a field force, the headquarters force comprising a chief executive officer, a deputy,

and any other experts attached to the main headquarters. The permanent field force should consist of division chiefs and deputies, each in charge of a unit of territory, possibly a county. These county or division chiefs and deputies should also act as inspectors and be responsible for the efficient work of the fire-protection force and lookouts.

The seasonal field force should be organized by groups of townships (about four townships to a group) or equivalent protection units with an administrative officer employed full time during the fire season in charge of each unit of area. They should carry on educational work by personal contact with the resident population, apprehend violators, keep fire plans up to date, and install patrols in times and places of special hazard.

For each such unit there should also be an organized suppression force paid by the hour or day and ready for action at any time. In addition, arrangements should be made for hiring temporary labor locally by the day as needed.

The detection system should include a sufficient and properly distributed lookout and patrol force, employed as needed during the fire season. The lookout and patrol men should be under the immediate charge of the division chiefs and their deputies.

EFFECTIVENESS

Among the first requirements for insuring the effectiveness of the fire-protective organization are of course adequate improvements and equipment, and well-thought-out plans for detection and suppression.

Improvements and equipment.—Steel towers with inclosed observatories equipped with maps and simple fire-finding instruments should be located at intervals so that the observer has not more than a 12-mile, or preferably an 8-mile radius to cover. A telephone system for quick communication between the lookouts and the men responsible for suppression is essential. There must be a transportation system which will provide for moving in fire crews in a reasonable time. Tools and fire-fighting equipment must be kept on hand at headquarters for the permanent field force, and at other strategic points. The tools and equipment should include not only shovels, saws, axes, mattocks, water bags, and water buckets, but for certain areas back-pack pumps, power pumps, and similar equipment. Pumps are not only desirable but necessary in certain areas, and with them fires can be suppressed at less cost than by the usual methods and by man power alone.

Among desirable safeguards against fire are the so-called fire lines. Fire lines are strips of plowed ground which serve as barriers to the spread of surface fires or as base lines for starting back fires. Fire lines are almost a necessity in valuable second-growth pine or plantations of pine on dry sandy soils, but less so in second-growth hardwoods or mature forests of either hardwoods or pine. They are considered indispensable on the Michigan National Forest and on some of the Michigan State forests, where large areas are planted

to pine. These lines are located either along subdivision lines, highways, or old logging railroads, wherever they may be most needed.

On the Michigan National Forest the fire lines are located largely along the main-traveled highways. They consist of two plowed strips of six furrows parallel with the highway on each side, each strip 7 feet wide and 30 feet from the center of the highway. A tractor with a heavy double-disk plow is used to turn over the sod. The tractor is also used for pulling stumps. The construction costs of such fire lines range from $50 to $75 per mile. The fire lines must be kept free of grass or other vegetation. They are, therefore, disked twice each year and the grass burned between the plowed strips. The width of the fire lines, as well as of the strips between them and the highway or subdivision lines, on which the brush or tree growth is cut or burned periodically, varies with the fire hazard of the locality.

On the Michigan State forests only single fire lines are used along subdivision lines. Such lines cost from $80 to $160 per mile. The cost of maintaining fire lines ranges from $5 to $18 a mile, according to the width of the fire lines and the intervening strips and also the age of the lines. With each successive disking the maintenance costs are reduced.

Standards of detection and suppression.—The detection force should be so organized that it can detect forest fires before they cover 0.1 acre. In the Lake States that means from 15 to 20 minutes after a fire has started. The outbreak of fire should be reported, and men should be actually on the fire before it has covered 10 acres. Under the conditions ordinarily prevailing in the Lake States that would mean within one or two hours after the fire has been detected. Of course there may be conditions where such speed would not be required, as, for instance, when a fire occurs in a type of forest where its spread must be slow or where it can be suppressed most easily during the night. The organization, however, should be such that, if necessary, a force of men could be put on any fire within one or two hours.

The organization for suppression of fire should be such that on an average it would not allow any fire to cover more than 10 acres. This of course can not be an absolute requirement, because when conditions are right fire will spread too rapidly for any normal control to be effective. But throughout most of the Lake States the conditions are such that no fire should remain uncontrolled overnight. Generally speaking, fire protection may be considered highly effective when the area burned over annually does not exceed five-tenths of 1 per cent of the total forest area, or 1 acre to each 200 acres of forest under protection. It is fairly effective even if 1 acre to each 100 acres is burned over annually, a goal that may take yet a few years for the Lake States to attain.

How near or how far the different States of the Lake States region are from adequate fire protection may be gathered from the figures in Table 4, based on a 10-year average (1916–1925), as ascertained in the fire-protection studies of the Lake States Forest Experiment Station. The figures for Wisconsin are estimated rather than actual, for in this State there are no reliable reports as to the number of fires and the area burned over.

TABLE 4.—*Ten-year-average fire record, Lake States, 1916–1925*

State	Area under protection	Total area burned annually	
	Acres	*Acres*	*Per cent*
Michigan	15,000,000	297,546	1.98
Minnesota	20,000,000	381,423	1.91
Wisconsin	6,000,000	148,422	2.47

Although a marked improvement in the reduction of the fire menace appears when these statistics are compared by five-year periods, the results are still a long way from the 0.5 per cent, or even 1 per cent, set as the criterion of desirable fire protection. Even on the national forests in the Lake States, where fire protection is more intensive than on other lands, the results fall far short of the goal. Thus on the Minnesota National Forest the area burned over annually (10-year average) is 1.4 per cent of the area under protection, and only about 60 per cent of the fires are discovered within 30 minutes after they have started and about 75 per cent within 1 hour. About 70 per cent of the fires are reached within 2 hours and 90 per cent within 4 to 6 hours after they are discovered. On the Michigan National Forest more than three-fourths of all the fires are discovered within 15 to 20 minutes after they have started, and are reached within two hours after they are discovered. On the Superior National Forest, because of the shorter fire season and smaller fire hazard, the annual area burned over is only 0.3 per cent of the area under protection; yet the fires that do occur cover a wider territory than in the other States, as only 10 per cent can be reached within six hours after the fires are discovered.

FINANCIAL RESPONSIBILITY

Experience indicates that under normal conditions and over large areas an efficient fire-protection organization, after it has become established and the initial cost of improvements and equipment has been met, may be maintained at an annual cost of 3 to 5 cents an acre for the area under protection.

The expense of fire protection may in the course of years be reduced by the removal of hazards and risks which are at present a source of fire danger. This is especially true in State forests or near-by private forests where, because of more intensive actual forest work, men constantly employed will always be on the ground. These men will normally take any measures that may be necessary to protect the forests and thus reduce expenditures for the distinctly protective operations. Likewise, as soon as large tracts of forests are placed under actual forest management, protection expenses, as such, will decrease. To these considerations must also be added the growing public sentiment against forest fires as a result of greater realization of the value of the forests.

Experience further shows that the most effective results in fire protection are obtained when the State assumes the entire responsibility for maintaining the central organization for protection of all forest land, but with the different parties concerned sharing in the

cost of maintaining and operating the organization and suppressing fires. It is believed that the maintenance of the fire-protective organization should be borne jointly by the State (aided under specific grants by the Federal Government) and by the timberland owners—the State dividing the cost of suppression with the local communities on a 50-50 or some other basis. The person responsible for starting a fire, however, should be liable for the entire cost of extinction.

Such a fire organization in the Lake States region, together with measures for reducing the danger from slashings, should provide effective fire protection for the forests of the region.

FIRE PROTECTION ON STATE LANDS

Although as a general rule fire protection is a prerequisite to forest management on private lands, in actual woods practice the two go best hand in hand. Whereas the proportion of the total forest land burned over annually in Michigan is nearly 2 per cent, and in the more adequately protected State forests about 1.2 per cent, in State forests where fire protection is coupled with forest management, as in the Higgins Lake Forest, the loss from fire is practically negligible.

The most important step toward bringing about more effective fire protection in this region will be to place the large areas of the State-owned forest lands under forest management; in other words, to organize them as State forests. The State of Michigan has close to 350,000 acres of State-owned land classed as forest reserve, but only 113,800 acres are under actual administration as State forests. In Wisconsin out of 338,000 acres of State-owned forest land, only 159,000 acres are forest reserves. In Minnesota, of 1,700,000 acres of State-owned land, 900,000 acres are in old timber. Of this, 380,000 acres are organized as State forests, but with little better provision for fire protection and management than is made for the rest of the State's forest lands.

If the large tracts of State-owned forest land were organized as permanent State forests with a permanent personnel for such work as planting, thinnings, and general upbuilding of the forest, good protection would be to a large extent assured. This would also be a cheaper and more effective way of securing efficient fire protection than to maintain an organization for fire protection only. Such forests would furnish concrete examples of forest management and also serve as a nucleus for a general fire-protection organization operating outside of the State forests.

PRIVATE EFFORTS IN FOREST-FIRE PROTECTION

Although State forest-fire protection is improving in the three Lake States, the more progressive timberland owners will hardly be willing to depend wholly on the State for fire protection and will want to insure additional protection for their own properties, just as the owners of large manufacturing plants, in addition to the fire and police protection afforded by the city, install fire-protective devices and maintain watchmen of their own. Thus the fact that the present State forest-fire organizations are not yet fully effective need

not deter progressive owners from growing timber crops. By cooperative effort they can soon secure for themselves fairly effective protection at a cost which, when considered as in the nature of insurance on the investment in standing timber, camps, and other equipment, is comparatively small.

In one instance in Minnesota, seven companies owning some 124,600 acres within 14 townships organized in the spring of 1919 a fire-protective association the members of which are bound by an informal written agreement renewed yearly. Control is in the hands of a board of directors, consisting of one representative from each member company. Active direction is given by an executive committee which includes the chairman and two other directors. Details of supervision, accounting, etc., are handled by the secretary, an employee of one of the member companies permanently assigned to fire-protection work. By the summer of 1922 the fire-protective work was sufficiently well organized to justify observation of the results obtained.

The experience of this particular cooperative fire-protection association during the five years to 1927 indicates that an average annual expenditure of between 18 and 19 cents per acre per year, including the cost of improvements and equipment, will give good protection and insure prompt suppression of such fires as have not been prevented on the land actually owned by the members. To secure proper protection from neighboring fires, however, it has been found necessary to extend the patrol area over 30 townships, or about 700,000 acres, making the cost about 3 cents per acre for the total area protected.

What this expenditure of about 19 cents per acre per year has accomplished is shown by a comparison of loss and cost figures for three years before and five years after effective protection was established, as shown in Table 5.

TABLE 5.—*Loss and cost figures before and after the establishment of an effective fire-protection system*

Year	Fire season [1]	Value of property destroyed	Area burned over
	BEFORE PROTECTION		
		Dollars	*Acres*
1919	Favorable	17,160	4,127
1920	Bad	3,022	835
1921	Favorable	55,886	7,979
	AFTER PROTECTION		
1922	Bad	2,223	1,097
1923	do	985	1,705
1924	Favorable	34	170
1925	Exceptionally bad	1,261	3,042
1926	Favorable	[2]	[2]

[1] Bad or favorable fire season refers to the general climatic conditions in the region during the fire season, and not to the good or bad luck the association had during that season.

[2] Loss insignificant.

Although the actual figures for 1926 for the area burned over and the value of property destroyed are not available, it is known that because of an exceptionally favorable season there were practically no forest fires. An eight-year period is of course not fully conclusive as to the effectiveness of the cost of such a fire-protective organization. The chief drawback is the necessity of protecting and fighting forest fires on land not owned by the members. In 1925 one member of the association dropped out, and, since the area in need of fire protection remained the same, the cost had to be distributed among a smaller number of members.

This expenditure, aside from keeping the land productive, is also somewhat in the nature of, although not strictly comparable to, fire insurance on standing timber, camps, and supplies. A forest tract of 124,600 acres represents in this region an investment of some $3,500,000, including camp and other equipment. The annual expenditure of $23,000 for fire protection may be considered equivalent to fire insurance at a rate of only 0.7 per cent. Considering that the average rate of fire insurance on sawmills is from 3 to 3.5 per cent and occasionally even as high as 7 per cent, the insurance on standing timber at 0.7 per cent is obviously very low.

In Wisconsin a pulp and paper company owning some 35,000 acres of readily inflammable jack-pine land provides its own fire protection at a cost of from 10 to 15 cents per acre, including improvements. During the period between 1911 and 1917, when no fire protection was provided, the company lost nearly 100,000 cords. From 1917, when fire protection went into effect, up to 1927 the entire loss was less than 500 cords. Like the Minnesota association, this pulp and paper company in order to protect itself from neighboring fires, patrols an area much larger than that which it actually owns. If the other owners concerned cooperated with this company the actual cost per acre would be only about 3 cents per acre per year.

Reasonably efficient fire protection, it is believed, may be obtained by private individuals through individual or cooperative efforts at about 3 cents per acre per year for a large continuous area under protection, a rather small expenditure considering the actual benefits derived. If the timberland is scattered, and the neighbors are unwilling to cooperate, the cost may be between 10 and 20 cents per acre for privately owned land—still not a prohibitive cost. The larger the area under patrol and the larger the number of neighbors who cooperate in the protection of their properties the smaller the cost. Since effective fire protection can therefore be bought at so small a cost, the fact that State forest-fire protection is not yet as complete as is desired need not be a serious deterrent to keeping forest land productive.

SLASH DISPOSAL—ITS EFFECTIVENESS AS A FOREST MEASURE

It is now generally admitted that unless careful precautions are taken slash left on the ground after logging is a distinct menace to the remaining forest and second growth, especially in pine forests. Although only a small percentage of fires may originate in slashings, it is the general experience that sooner or later all slash is burned.

It is coming, therefore, to be generally recognized that some manner of slash disposal, or the alternative of more intensive fire patrol, is a necessary measure in reducing fire hazards and in making fire fighting easier when fires do break out. From a fire-protection standpoint the need of slash disposal is greater where there is less effective general fire protection. The more effective the fire protection and patrol the less need there is for special disposal of slash.

Slash from conifers left on the ground to rot hinders reproduction. A heavy layer of slash, particularly in the conifer types, will prevent many a seed from reaching the mineral soil. Many of the seedlings that are already established or that start under the slashing are killed by the heavy tops and branches, although a few are afforded protection.

But the greatest menace of slash is the hazard to which it subjects reproduction in the event of fire. If fires run through a slashing they destroy all young growth and even burn the soil to such a depth that reproduction is almost impossible for many years. In high winds, slash fires can not be controlled with any equipment that man has at his disposal.

For all these reasons it is desirable to have the cut-over land cleaned up, either by disposing of the slash entirely or by reducing it to such an extent that it can do relatively little harm.

The cheapest and most effective method of slash disposal is close utilization. Where pulp wood is being utilized down to 3 or 3.5 inches in the tops, or where the hardwood tops are being used for chemical wood, the slash is light and the danger is comparatively small. In European countries, where there is close utilization, slashings as a fire menace do not exist. In this country the slash problem will also solve itself eventually as market conditions justify close utilization in the tops of the trees and as partial cutting becomes more general.

In the meantime, where pine and hardwood tops 7 or 8 inches in diameter are unutilized, the considerable slash remaining on the ground is both a hindrance to natural regrowth and a distinct fire menace. Some means, therefore, of cleaning up the ground after cutting is essential if the cut-over land is to be kept reasonably productive.

The general public has always associated large forest conflagrations such as have occurred from time to time in the Lake States with the large accumulations of tops and branches left in the woods after cutting. In Minnesota, public opinion forced the passage of a compulsory state-wide slash-disposal law. This law gives discretionary power to the State forester to prescribe certain methods of making the cuttings safe against fire danger and, on the whole, has been beneficial. It is to the interest of the private forest-land owner, as well as of the public, that there should be a State law which makes it unlawful for any careless operator to leave his cuttings in such shape as to endanger adjoining forest land which may have promising second growth timber coming up. There is still, however, considerable difference of opinion as to the best method of slash disposal and as to the actual cost of the extra operations which may be involved.

Four methods of slash disposal have been tried out in the Lake States at different times and under different conditions with varying results: (1) Broadcast burning, (2) piling and burning later, (3) piling and burning progressively as logging proceeds, and (4) lopping of tops without burning.

BROADCAST BURNING

At one time broadcast burning was the usual method used in Minnesota. The accepted practice was to wait until a warm day in May and then to set a fire in the southwest corner of the slashing. This practice has not worked out well. The result of the broadcast burning of slash has been that great areas have been cleared not only of slash but also of all the valuable trees that were left on the ground. Lumbermen burned the slash chiefly at the time when it would burn best, thereby causing much destruction of young growth. The trees killed by the slash fires have later fallen and created new fuel, often as great a fire menace as the original slashing. This method, even under the best auspices, is dangerous and results in unnecessary soil depletion. Broadcast burning of slash in the woods is, therefore, to be avoided under all conditions. No broadcast burning should be resorted to even for clearing the land for agriculture.

PILING THE SLASH AND BURNING LATER

The method of piling slash after logging and burning the piles when weather conditions are favorable, usually late in the fall after the first snowfall or early in the spring, has been tried in Minnesota and Wisconsin. If the piles are small and not too close together, the result is usually a thorough burning. If the piles are too large or too close together, the fire is apt to become uncontrollable and result in a broadcast burn. It has been objected that the piles are often disturbed in skidding and have to be piled again before burning, which increases considerably the cost of burning. If the slash disposal is planned and carried out properly this extra cost can be avoided entirely.

PROGRESSIVE BURNING AT THE TIME OF LOGGING

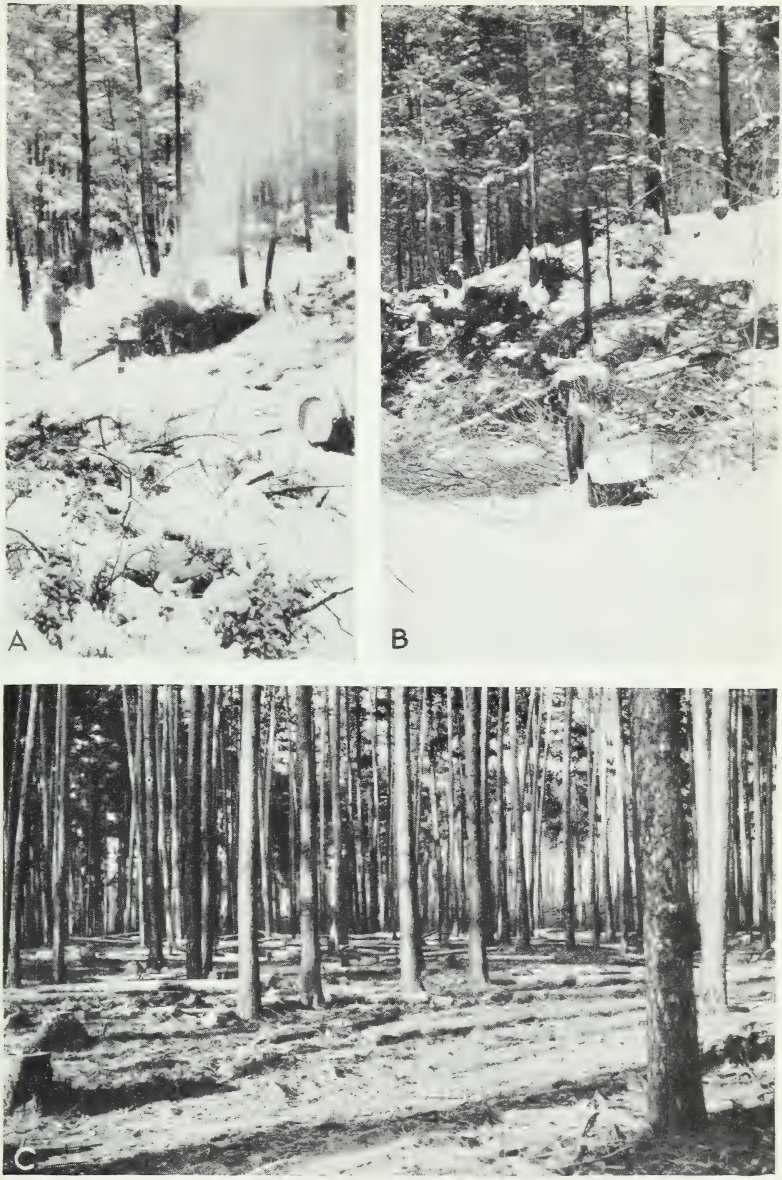
On the timber cuttings on the Minnesota National Forest and on some hardwood holdings in Michigan progressive burning at the time of logging is a method used with good results. Fire is started with some dry wood, and the green brush as it is produced is then piled upon the fire, the slash being completely disposed of as it is swamped. As a result of burning progressively in advance of skidding, a team will skid 15 to 25 per cent more logs a day than where the brush left during logging makes it necessary to cut skid trails.

This method has been thoroughly tried out in this region for nearly 20 years and has proved successful and inexpensive. It has several distinct advantages:

(1) It results in good slash disposal.

(2) It removes the slash before skidding, which reduces the cost of logging.

(3) It saves rehandling the slash.



SLASH DISPOSAL IN TWO TYPES

A hardwood forest in northern Wisconsin where slash has been piled and burned along roads (A); elsewhere the tops are lopped and scattered (B) without burning. In the Norway pine stand (C) on the Minnesota National Forest the slash was burned at the time of logging and before skidding, at low cost and with a saving in timber salvaged as a result of the clean-up. (F-13104-A)

(4) Fires are easily controlled and do little or no damage to any standing timber and young growth on the land.

(5) Progressive burning destroys less of the soil humus and vegetable matter than any other method of burning.

(6) It saves logs that would otherwise be left in the woods.

LOPPING OF TOPS WITHOUT BURNING

The method of lopping of tops without burning is used in hardwood cuttings on the Minnesota National Forest and also by some hardwood timber operators in Wisconsin. It is a satisfactory method where utilization is close and where effective patrol is provided to prevent fire during the years immediately following. It has also the advantage of conserving the humus, especially on thin or rocky soils.

EXAMPLES OF SLASH DISPOSAL

Below are given actual instances of slash disposal—the method used, the cost, and the results obtained.

IN HARDWOOD FORESTS

On a timber operation in the Upper Peninsula of Michigan progressive piling and burning was tried. The branches and tops under 3 inches in diameter were piled and burned as logging progressed. To accomplish this to the best advantage, a crew of swampers followed the falling crews, lopping the tops and piling and burning the slash as they went. The result was easy skidding and a cut-over area free from the hazard of ordinary logging slash.

Since by this method most of the slash is burned in the winter when there is snow on the ground, or in the summer when the woods are green, there has been very little damage done to standing trees or to advance reproduction. In the spring and fall, however, fire is inclined to run, and at times it has been found necessary to discontinue burning in these seasons. According to the foreman, no difficulty is experienced in burning slash green or in the winter, once a fire is started. The practice of burning as the slash is piled materially reduces the number of brush piles and consequently the area burned over. Burning on the snow also helps to minimize the damage, as the ground is often scarcely charred—a strong argument for winter burning.

While progressive piling and burning the slash does not make a cut-over area fireproof, it makes fire control easier and insures the prompt reestablishment of a forest cover. The latter is strikingly brought out by a comparison between an area on which slash has been piled and burned at the time of logging and an adjoining area cut over shortly before and left to burn off in the usual manner. The slash hazard on the two areas at the present time is practically the same, as is also the amount of timber left standing on each. On the area on which the slash was left to burn off, however, nearly every tree left standing has been killed, and except for a little scattered sprout growth the area is a tangle of weeds and grass. On the adjoining area where the slash has been piled and burned, the trees left standing are alive and thrifty, and an excellent stand

of hardwood sprouts and seedlings (the latter mostly maple) has come in, while weeds and briars are conspicuous by their absence. In a comparatively few years the forest cover will have reestablished itself on this area, and the fire hazard will be reduced to a minimum. The area burned over will continue to be a fire hazard for years to come, as there is little prospect of the early reestablishment of a forest cover. A conservative estimate is that the area over which the slash was piled has at least a 10-year start over the other in the matter of reforestation.

On one of the sample areas examined in detail were 29 brush piles, of which 4 had not been burned. The diameter of the average burned spot was about 15 feet, making the total burned-over area approximately one-tenth of an acre, or 10 per cent.

The cost of slash disposal on this tract is in the neighborhood of $2 per thousand board feet. It is estimated that $1 of this is offset by reduced logging costs resulting from the disposal of slash, approximately 75 cents per thousand being saved on skidding and 25 cents per thousand upon logs that would otherwise be overlooked and left in the woods. There is also an appreciable saving of horseflesh.

Another example of hardwood slash disposal is that of piling and subsequent burning as it was at one time done on the Menominee Indian Reservation. The slash there was loosely thrown together in large piles at the time of logging and burned in the fall. The men in charge of this operation considered that because of the benefits resulting, the piling and burning of the slash did not constitute any addition to logging costs. Some of the contractors working on the reservation, lumbermen of 40 years' experience in the woods, were sure of this. They paid the sawyers by the log and required them to pile the slash as they went along. This reduced the number of swampers from three for every two skidding teams to one, and in a pinch to none. At the wages paid at that time this saving amounted to from 30 to 45 cents per thousand. They felt that piling saved from 5 to 10 per cent of logs, which otherwise got buried. It was easier on the horses and the sawyers, and after the sawyers got used to doing it their work was so facilitated that they would not have had it otherwise.

The piling and burning of the slash on this hardwood operation was certainly economically justified, and it was claimed to be a good fire-protective measure; but it can not from a silvicultural standpoint be considered a success. The large piles loosely thrown together burned fiercely and, as a rule, burned over the entire area. It amounted, therefore, practically to broadcast burning.

A third illustration, of method and cost of disposing of slash in hardwoods by lopping and leaving, is offered by a small logging operation in Wisconsin. The method of disposal consists of so lopping the tops and limbs that they will lie flat on the ground. Large limbs lying together are scattered. Along roads, trails, and other frequented places the tops are piled and burned to reduce the fire hazard and to improve the appearance of the forest. (Pl. 3, A and B.) These provisions, included in the contract, have been carried out at a cost of 40 cents a thousand board feet cut and may be considered as satisfactory both silviculturally and as fire-protection measures.

IN NORWAY, WHITE AND JACK FORESTS [3]

On the Minnesota National Forest, where the logging operations are in Norway, white, and jack pine stands, the slash is burned progressively at the time of logging. This method with some modifications has been in use for over 20 years and has back of it the experience and sound judgment of many practical men.

The cost varies in stands of different qualities and densities, in no case exceeding 75 cents to $1 a thousand board feet logged. The mental attitude of the operator is usually reflected in the cost of the work. Some operators maintain that the cost of clearing the ground is practically offset by the increased number of logs they can handle per day; while others who are not convinced of the need of brush disposal and do it grudgingly and in a hit-or-miss manner with men spared from other lines of work complain that the costs are high.

The disposal of brush by progressive burning has become especially effective and inexpensive with the introduction of the so-called "gyppo" or piecework system about four years ago. The "gyppo" introduces better teamwork and creates an incentive for efficiency. Two experienced pieceworkers will fell all their trees toward a given point with the trunks radiating from it like spokes from the hub of a wheel, with the result that the tops of 10 to 20 trees may be burned on one fire. This not only saves time for the sawyers, but also reduces the area actually burned over. In one instance, all the slash on 1 acre of jack pine that cut 15,000 board feet was burned in four piles covering in all a little over 1 per cent of the acre.

On another job, on which the logging was done during the winter of 1924–25, the timber was jack pine varying from a few trees up to 15,000 board feet per acre. The trees averaged 2.5 to 3 logs to a tree and the logs ran about 30 to the thousand. Logs were cut to a minimum top diameter of 6 inches, and pulpwood out of the tops to a minimum diameter of 4 inches. The operator paid 10 cents a log and 3 cents a stick for jack-pine pulpwood, including felling, bucking, and brush disposal. A crew of sawyers averaged each day 1 cord of pulp wood (50 sticks) and 105 logs, at a cost of $12 a day, or about $3 a thousand board feet for the whole operation. Observation showed that 25 to 35 per cent of the time of the sawyer was actually spent on disposing of slash, including all limbs and unmerchantable material under 8 inches in diameter. This made the expense for slash disposal about 75 cents a thousand board feet logged. One man and team can skid, under average conditions, about 2,600 board feet a day at a cost of $4.05 per man and horse, or at the rate of approximately $1.55 a thousand board feet. With the slash burned before skidding, one man and team will skid about 3,250 board feet per day, a saving of 30 cents a thousand board feet directly attributable to slash disposal. In this particular operation the net cost of slash disposal was therefore 45 cents a thousand board feet.

On another operation, cutting Norway pine entirely, the net cost of progressively burning the slash, after crediting the saving in the cost of skidding, ranged from 33 to 58 cents a thousand board feet.

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[3] MARSHALL, C. E., and CUMMINGS, M. J. SLASH DISPOSAL IN NORTHERN MINNESOTA (Amer. Lumberman, Jan. 29, 1927).

These are the costs in actual operations in average stands of white, Norway, and jack pine. In heavy stands of tall, clear timber the cost is less. In scattering stands of shorter timber with heavy tops the cost is naturally greater.

Progressive burning in the pine forests is considered a practical and most inexpensive method for the operator. The slash is burned at the time when there is no fire danger. The damage that is done to the remaining timber and the area covered by the fires is reduced to a minimum, and the forest is left in good condition for a future crop. The cost of burning slash should range from 75 cents to $1 a thousand board feet on any job that is handled in a workmanlike manner, and if this cost is further credited with the saving in skidding it may be reduced to as low as 35 cents a thousand. (Pl. 3, C.)

IN SPRUCE AND BALSAM FIR FORESTS

Careful experiments as to method and cost of slash disposal [4] were conducted in Manitoba in spruce and balsam fir forests, very similar to those in northern Minnesota. The method employed was in some instances burning at the time of skidding, and in others burning immediately after felling and before skidding.

In one experiment it was found that when the slash was burned at the time of logging, but while skidding was going on, the cost of swamping, skidding, and slash burning was $2.41 a thousand board feet, whereas swamping and skidding alone without slash burning was $2.07. In other words, the burning of slash added 34 cents a thousand feet board measure to the cost of logging.

In another experiment where the slash was burned before skidding, the cost of swamping, skidding, and slash burning was $1.39, while the cost of swamping and skidding alone without slash burning was $2.07. In other words, there was an actual saving of 68 cents a thousand because of burning the slash.

In another experiment, conducted in a tie operation, the cost of felling, swamping, and skidding without slash burning was 13.3 cents a tie or $4.39 a thousand board feet; whereas the cost of felling, skidding, and burning the slash immediately following cutting was only 11.6 cents a tie, or $3.83 a thousand feet. In other words, slash burning reduced the actual cost of felling and skidding by 56 cents a thousand feet, a net gain in logging operation.

Additional data were obtained from nine logging operators, to show the variation in cost of slash disposal regardless of the method employed. These costs varied from 60 cents to $1.15 a thousand board feet, with an average for all nine operators of 80 cents.

IN OTHER STANDS

The experience in handling slash in such stands as aspen and birch, and in tamarack, spruce, and cedar swamps is extremely meager. The policy followed by the Forest Service in aspen stands on the Superior National Forest is merely to lop the slash. Tamarack, spruce, cedar, and balsam fir slash is burned progressively, as is

[4] STEVENSON, H. I. SLASH DISPOSAL BY BURNING. The Illustrated Canadian Forest and Outdoors. Aug.–Sept., 1924.

pine on all areas where fire conditions warrant. In swamp areas or isolated patches, such as hummocks of high land within the spruce swamp, where fire danger is not great, the limbs are lopped but not burned. Cutting in these stands on the national forests has been so infrequent that no conclusions as to the cost and effectiveness of such slash disposal are warranted.

GENERAL CONCLUSIONS REGARDING SLASH DISPOSAL AND ITS COST

From the examples cited it is fairly clear that the cost of slash disposal in hardwoods and conifers may vary according to the method used from an actual saving in the cost of logging to $1 additional for each thousand board feet cut.

The burning of slash in pine and spruce timber on highlands, according to timber operators themselves, should cost at most but $1 per thousand board feet. Even this amount or part of it may be saved through reduction in the cost of swamping if the slash is burned before the logs are skidded. The lopping of hardwoods and conifers in swamps and the burning of slashing along skidways, rights of way, and protective fire zones can probably be accomplished at a cost of 25 to 40 cents per thousand board feet.

It must be borne in mind that the estimates of the cost of slash disposal advanced by timberland owners are as a rule merely guesses. The few actual figures obtained would indicate that slash disposal is not expensive and that it occasionally results in a net saving in the cost of logging, through facilitating skidding and through the salvage of logs which would otherwise become covered with slash and be left in the woods. A point brought out by the Canadian experiments is that slash disposal should precede skidding and be done just as soon as the trees are felled. This leaves the logs on the ground in such a way that the skidder teamsters can do the work alone, no swampers being required and no logs being overlooked. When the timber operators realize the advantages of disposing of slash as a part of logging operations there will be no need of any compulsory regulations. They will do it voluntarily because of the saving effected through the reduction in the number or the entire elimination of swampers.

It must be further remembered that slash disposal is not yet commonly practiced by private operators unless under compulsion, as in timber cutting on the national forests. For this reason the cost is comparatively high. When slash disposal becomes a regular part of logging operations, and willing and experienced men are assigned to handle it, the cost may reasonably be expected to be considerably less. But even the present cost is not excessive.

Disposal of coniferous slash by burning in winter or in midsummer at the time of logging, as a general principle, should be strongly recommended, not only on national forests, where it is already in practice, but also on all State forest lands on which timber is being cut and on private lands which are to be devoted to timber growing.

On private timberlands, even though the cost of disposal of all slash over the entire area by burning at the time of logging is not prohibitive and the method offers many advantages, a simplified

procedure may be adopted. Where the cut-over area is effectively protected against fire it is not absolutely essential that all the slash should be burned, provided that it is disposed of at certain places. This simplified procedure, however, may be adopted only on condition that there is effective fire protection.

No method of slash disposal will make the forest fireproof, but slash disposal does help to make fire protection easier and clears the ground of unnecessary débris that hampers natural regrowth. On the other hand, effective fire protection of the timber tract is absolutely essential to make the expenditure of money for slash disposal a sound investment.

The Lake States, with the exception of Minnesota, do not have provisions such as exist in most of the Northeastern States for the disposal of slash as a public nuisance. The development throughout the entire northern region of highways traversed by literally hundreds of thousands of tourists, is creating a public demand that the forests along the highways should not be cut, slashed, and burned carelessly and the beauty of the highways destroyed. Some law for slash disposal along highways may, therefore, be demanded for aesthetic reasons alone, and a law to this effect was, indeed, passed in Michigan in 1927. It is desirable in the interests of private timber owners, as well as the public, that there should be general laws for slash disposal in all the States similar to that now in effect in Minnesota. Such laws, however, should not specify, except possibly for the forests along highways, the exact manner in which the slash should be disposed of, since this will vary with the character of the forest, the organization of the forest services, and the ability of the forest organization to enforce the degree of protection required.

Some form of slash disposal by all timber operators makes everybody's timber safer. If some do and some do not, those who do dispose of their slash are still at the mercy of their neighbors who leave fire traps.

LOGGING PRACTICE

CUTTING TO A DIAMETER LIMIT

At present saw logs are cut to a top diameter of about 6 inches in softwoods and 7 inches in hardwoods. This means cutting pine to about 8 or 9 inches in diameter breast high and hardwood trees to 10 or 12 inches. Studies of the comparative costs of cutting small and large logs show that to cut small trees for logs costs decidedly more than to cut larger trees. In one hardwood operation the cost of logging 8-inch maple logs from stump to mill pond was $21.14 a thousand feet gross Scribner scale, whereas for 24-inch logs the cost was only $8.64. The cost of logging the 8-inch timber was 145 per cent per thousand feet more than the cost for the 24-inch logs. The cost of logging trees 12 inches in diameter breast high was $16.13 a thousand feet, or 61 per cent greater than the logging cost of $10.03 for trees 25 inches in diameter. The milling costs of smaller logs were proportionally higher and the amount of upper grades lower for small logs than for large logs. The conclusion reached on the basis of these studies—and this is also confirmed by the experience of old loggers—was that trees below 13 or 14 inches in diameter are

being logged largely at a loss, which must be covered by the profits obtained from logging larger trees.

It is, of course, impossible to avoid taking small logs in a logging operation, as even the largest trees will have small logs at the top. By limiting the cutting, however, to trees 13 or 14 inches and over in diameter, the proportion of small logs handled in any logging operation may be greatly reduced, with a considerable reduction in the cost of logging and therefore a proportionate increase in the profit. Leaving trees below 13 or 14 inches in diameter standing in the forest will make possible a second cut of saw-log material within 30 or less years, according to the species, will provide for abundant seeding of the ground, and will leave the land in a good productive condition. In certain instances, of course, danger from windfall or heavy investment in railroad construction may necessitate cutting all trees of merchantable size, either for saw-log material or ties and mine props. Under the conditions prevailing in the Lake States, however, cutting to a diameter of 13 or 14 inches, especially in hardwoods, is not only possible but economically more profitable than including trees below these sizes.

SAVING YOUNG AND UNMERCHANTABLE TREES IN LOGGING

As a general rule there is too much unnecessary destruction of young trees in logging. With ordinary precautions in felling the larger trees and without additional cost, much of this young growth can be saved. The more young trees that are saved in logging, the more advanced will be the regrowth of the logged-off land and the shorter the lapse of time until the land can be logged again. On an average for three hardwood logging operations studied, the logging damage to trees which survived amounted to at least 15 per cent of those between 6 and 10 inches in diameter breast high. This does not include the very heavy damage to trees below 6 inches in diameter, consisting largely of breakage of tops, heavy bruises, and other injuries which made the chances of recovery very poor. This damage is typical of most hardwood operations, but with simple precautions it can be reduced to, at most, 5 per cent of the trees left on the ground.

CUTTING TIMBER AROUND LAKE SHORES

Much of the northern country is becoming more and more appreciated for its recreational value. A considerable source of revenue is obtained from shore properties as summer homes, especially when they are surrounded by green timber. It may be desirable, therefore, to modify logging in such a way as not to destroy the scenic value of the locality.

Where timber occurs along lake shores or streams, or where it is desired for scenic purposes, logging should be carried on in such a way as to preserve the scenic value of the forest. Only dead and diseased trees should be taken out, and the forest cover should not be disturbed. In Minnesota the law prescribes that no logging shall be carried on along the lake shores and streams within a strip 100 feet wide.

STABILIZATION OF FOREST TAXATION

The forest-tax situation is showing improvement in the region. All the three States have now passed special forest tax laws.

There is no denying that the valuation of forest land for purposes of assessment is very haphazard. While some land may receive as low a valuation as $1 to $1.50 an acre and the young growth not be taxed at all, in other places land entirely bare of tree growth is assessed far in excess of its real market value. With no standard by which such forest land should be taxed, too much play is allowed for personal opinion, the needs of the township or county for revenue, and similar considerations. Even without special forest-tax legislation the present property tax, if based on a reasonable and true valuation of forest land, could go a long way to remedy the situation. As the forest-land owners devote more and more of their cut-over land to growing timber, a change is bound to come through which the land will be assessed at its true value and subjected only to its just share of the taxation burden.

FINANCIAL ASPECTS OF TIMBER GROWING

There is a general misconception of the cost of timber growing. For some reason timberland owners consider the reforestation of their cut-over areas as an entirely separate financial operation from the rest of their timber business. From the standpoint of financial policy and accounting technic they look upon reforestation as a separate long-term investment which at the end must pay for all the carrying charges at compound interest and still leave a fair profit to the owner.

This theory of forest finance is based on the old conception formed in the days of "unlimited timber resources," that the forest is a mine, that the operation ends with the removal of merchantable timber, and that with the removal of this timber the asset itself is destroyed and the capital withdrawn.

If such a principle were applied to any other continuous business, it would lead within a short time to the elimination of the industry. Any industry to be perpetuated must retain its assets intact, the profits being only the dividends on the capital invested. The permanent capital itself, as it is withdrawn with the sale of the goods, is reinvested in the business. For instance, a wholesale dry-goods business with a certain permanent capital, as it sells its goods, reinvests part of the proceeds in replacement of stock. Out of the annual proceeds, in addition to replacement of the stock, are also paid the operating charges such as maintenance of buildings, insurance of stock, sales costs, and transportation. If it becomes necessary to build a new warehouse the interest on the capital in the warehouse and depreciation are paid out of the current business. The same is true if the business is financed by bonds; the interest on the bonds and the sinking fund for their redemption come, in any sound business, from the current revenue.

If the lumber industry is to be converted from an industry which destroys its assets into an industry with a permanent invested capital in growing timber, it must inevitably adopt the same principle.

Timber growing as a permanent business must consider reforestation of the logged-off lands as a part of its timber operations and as an absolute condition for continuous forest production.

The maintenance of the cut-over land in a productive state and stocked with trees of all sizes is as much a necessity for the lumber industry as it is for the wholesale dry-goods merchant to keep on hand a full stock of his goods, or for a manufacturer of high-grade, air-seasoned lumber to keep on hand stacks of lumber at different degrees of dryness. In each instance the replenishment is a charge against the annual proceeds of the business.

As a matter of fact, the lumber industry is already regularly reinvesting the proceeds from its current business, by putting these into stands of mature timber. The migration of the lumber industry from the Northeast to the Lake States, to the Southern States, and to the West is a concrete illustration of this process. The reinvestment of proceeds in the productive power of the cut-over lands in the same region does not therefore involve any new financial principle. It moreover has distinct advantages. Investment in old timber is becoming increasingly difficult because of shortage of supplies, and in time it will become impossible. The timber purchased must be carried for many years, yielding to the owner meanwhile only the advantage of possible increase in stumpage values. Little is to be expected from increase in growth or increase in quality, for the timber is past maturity. On the contrary, there may be actual loss through physical deterioration. Reinvestment in the young growth on the cut-over land in the same region provides three sources of increase in value: (1) The increase in growth; (2) the increase in quality with age; and (3) the increase in stumpage value. If to this is added that the investment in the cut-over land is already made and must be carried anyhow, reinvestment in second growth in the same region should from a financial standpoint prove more attractive than investment in old timber that is past maturity.

Forestry can not, any more than any other business, be shown to be highly profitable if investments in reforestation of logged-off land are to be treated as a separate operation from the standpoint of financial policy and accounting technic; if they are to be computed at a high rate of compound interest, the proceeds from which at the end of the period must cover all the carrying charges in addition to a certain profit.

Compound-interest charges are justifiable only when a forest-land owner, having removed all the merchantable timber from his property and being no longer a timber producer, decides to invest in cut-over land. Under such conditions there is no annual income, and the money put into reforestation must be considered purely as a long-time investment. Such investments are, as a general rule, not at present attractive to private owners and can best be carried out by the Federal Government, States, counties, municipalities, and other public agencies.

Without attempting to show just how profitable timber growing may be to going timber concerns, an illustration is given here of the manner in which financial computations should be made to determine the possible profits under certain conditions.

An owner of a jack-pine tract of, say, 40,000 acres, wishes to devote his land continuously to growing jack pine. What are the elements of cost and the basis for figuring the possible returns from such an enterprise?

Jack pine in 40 years, with only protection of the growing stands from fire, will produce on an average about 20 cords per acre, including good, medium, and poor soils. Let us assume that the owner logs every year 1,000 acres. In 40 years he will, therefore, cut over the entire tract. At the end of the 40 years, the first 1,000 acres, which he logged, say, this winter, will, if the land is given fire protection, be ready to cut again, and the same will be true of every successive 1,000 acres logged.

The average stumpage price of jack pine at present is $1 a cord. The returns from the 1,000 acres, if the average stand of the tract logged is 20 cords, would represent an annual gross income of $20,000 for stumpage alone, or on an acre basis, $20.

The cost involved in producing continuously this gross income is the protection of the entire 40,000 acres from fire, or, for every acre cut, 40 acres protected. Assuming 10 cents per acre as the cost of fire protection, the owner will have to spend every year out of every $20 gross income per acre $4 for protecting 40 acres from fire; for the 40,000 acres, $4,000. In addition, of course, there will be the annual taxes to pay on the entire tract out of the income for the 1,000 acres cut, or on 40 acres from the income from 1 acre cut. The taxes vary all the way from 10 cents to 35 cents per acre for cut-over land. Assuming 15 cents per acre as the usual annual tax on jack-pine land, that would mean $6,000 on the entire tract, or $6 on 40 acres. There will be in addition the cost of slash disposal, amounting to 17½ cents per cord. This item is charged to logging cost in assuming a stumpage value of $1 a cord. The value of jack-pine land is at most $1 per acre, which must be considered as a permanent investment, and only the annual interest of, say, 4 per cent must be charged against the annual gross income. The total computation, then, is as in Table 6.

TABLE 6.—*Annual costs and returns; 40,000 acres of jack pine under crude forestry; 20 cords per acre on 1,000 acres cut annually over 40 years*

Item	Costs	Returns
20,000 cords cut annually on 1,000 acres, at $1		$20,000.00
Fire protection, at 10 cents per acre, 40,000 acres	$4,000.00	
Taxes, at 15 cents per acre	6,000.00	
Interest at 4 per cent on land valued at $1 per acre	1,600.00	
Annual cost of carrying 40,000 acres		11,600.00
Net return on 40,000 acres		8,400.00
Net return per acre cut		8.40
Net return per acre owned		.21

The growth removed from an acre of mature timber represents the annual growth of 1 acre for 40 years or the growth of one year on 40 acres. By protecting from fire 40 acres the owner secured the growth which he removed from 1 acre of mature timber. His assets, therefore, are not destroyed but simply reinvested, and the profit of

21 cents per acre merely represents the dividend upon the permanent capital invested in growing timber.

This calculation is very conservative, as there has been no allowance for stumpage increase in jack pine, and the cost of fire protection is placed very high. Jack pine in some localities brings even to-day $2 per cord. Within 10 years $2 will unquestionably be the average price. The returns may be expected, therefore, to be at least double what they are now. On the other hand, with better fire protection provided by the State and better general slash disposal throughout the region, the cost of fire protection to the private owner should become less. This provides sufficient leeway to take care of occasional forest fires that may occur and damage from insects, fungi, or from other causes.

MANAGEMENT OF FOREST LANDS AND WHAT IT INVOLVES

Any private owner who desires to go into the growing of timber crops will sooner or later not be satisfied with merely protecting his cut-over land from forest fires and utilizing only one-third of the productive capacity of the soil but will want to go into more intensive forest practice in order to utilize 70 to 90 per cent of the productive capacity of the soil. This necessitates a consideration of what is further involved in the management of forest land to produce full timber crops.

INTENSIVE FORESTRY PAYS WHERE CRUDE FOREST PRACTICE MAY NOT

Many of the older civilized countries have been carrying on timber growing with success for years. Forest practice is carried on successfully in European countries under different types of ownership. In Germany 47 per cent of the forest land is privately owned; in France, 65.5 per cent; and in Sweden, 76.4 per cent. In all of these countries forestry is considered a safe and profitable industry, and continuous forest production is the common practice on private lands.

The stumpage prices in some instances and for some grades and species are undoubtedly higher but not very much higher than in this country. On the other hand, while labor costs are lower, land values are much higher than here. Then why is intensive forest practice so little applied to the large privately owned timber tracts in this country?

Fear of fires that may destroy in a few hours the accumulated forest capital of years is undoubtedly one of the great deterrents to the practice of forestry by private landowners in the United States. Yet fire protection in some of the Lake States is now reaching a stage where the forest may be considered a reasonable risk, and it will become still better as more forest land is handled for permanent forest production. The bogey of high taxes is another deterrent—in some instances the high present rate on cut-over land, but more especially the uncertainty of future taxes. But forest taxes are higher in some other countries, and yet do not prevent the forest owner from practicing forestry; as a matter of fact, they drive him

on to more intensive practice to offset their burden. The main obstacle to the practice of forestry in this country is the mental attitude which fails to regard the forest as a permanent, crop-producing entity and which takes no cognizance of the possible profits in permanent forestry as compared with the destructive "mining" of timber from forested land.

Practical forestry should not consist in starting with cut-over and ruined lands and planting new forests which will not be ready to harvest for 100 or 200 years. Such forestry will seldom be profitable to any private owner. It is an enterprise which only the State or National Government can undertake.

Forestry in the old countries, and the same will be true in this country, began almost entirely with tracts of existing forests managed for continuous production. This involves handling the old stands so as to prolong their life and insure their reproduction and at the same time stocking up the cut-over land in such a way that the whole forest is able to sustain in continuous operation some wood-using plant of efficient size. It necessitates reforestation as the mature timber is removed, taking advantage of the young growth that has sprung up on the cut-over land, improving it and possibly planting here and there the blank acres which nature has failed to restock.

The practice of forestry, therefore, should particularly appeal to timber owners who have standing timber sufficient to keep their plants going until the young growth is ready to supply raw material. If there is not enough old timber left, what remains should be conserved as far as possible by buying logs until the annual growth of the forest in question is equal to the needs of the operation.

Under destructive logging, where the old timber is removed without regard to the future of the forest, the only return that the timber owner gets is from the increase in the market price of the stumpage and the land. Under permanent-forest practice there are returns from at least three other sources: (1) Increase in the volume of the timber through growth, (2) increase in the quality of the timber as the young timber increases in size, and (3) decrease in the depreciation of the plant and equipment through the extension of their life.

An authority[5] on bond investment states: "There is probably no material, not even gold itself, which has future value in exchange more assured than wood. Lumber value has had no material setbacks in the past 20 years at least; and the tendency has been constantly upward."

Experience in the Lake States shows that stumpage prices for the three typical hardwood species—beech, yellow birch, and hard maple—increased on an average 21 cents each year for the period between 1900 and 1924, and aspen increased at the rate of 5 cents per year during the period from 1910 to 1924. The period of greatest annual increase in stumpage for beech, birch, and maple was between 1919 and 1924, as may be seen from Table 7.

[5] CHAMBERLAIN, LAWRENCE. THE PRINCIPLES OF BOND INVESTMENT. New York. 1927.

TABLE 7.—*Stumpage prices per thousand board feet for beech, birch, maple, and aspen for certain years, and average annual increase in price, 1900–1924*

Year	Beech		Birch		Maple		All species [1]—average annual increase	Aspen [2]	
	Price	Average annual increase	Price	Average annual increase	Price	Average annual increase		Price	Average annual increase
1900	$1.50		$1.65		$1.75				
1904	1.90	$0.08	1.85	$0.04	2.05	$0.06	$0.06		
1909	2.65	.15	3.40	.31	3.40	.27	.24	[3] $1.65	
1914	2.90	.05	4.35	.19	4.40	.20	.15	1.70	$0.01
1919	5.00	.42	4.90	.11	5.25	.17	.23	2.05	.07
1924	6.65	.33	6.50	.32	7.20	.39	.35	2.35	.06

[1] Average annual increase in stumpage price for 25-year period, $0.21.
[2] Average annual increase for 15-year period, $0.05.
[3] 1910.

If these rates of increase continue, stumpage prices should double in about 40 years.

The increase in stumpage prices for trees of the smaller sizes or for trees that have low stumpage value is greater than that for trees already having a fairly high stumpage value. Thus, a present stumpage price of, say, $6 a thousand increasing at the rate of 21 cents a year, with taxes at the rate of 1 per cent of the actual value and other holding costs at 1 cent a thousand board feet, nets the investor approximately 2 per cent on his investment from the gradual increase in the market price of his stumpage. On the other hand, timber worth to-day, say, $2 a thousand board feet and increasing in market price at the same rate nets the holder 8.5 per cent from this increase.

The increase in the volume of timber through growth in the Lake States, under forest management, will not exceed 3 per cent a year.

The increase in the quality of the timber as it increases in size can be set probably at not less than 1 or 2 per cent per year, while the decrease in depreciation of the sawmill or pulp-plant equipment may prove a saving of another 1 or 2 per cent per year.

There is still another advantage to manufacturers of wood pulp or other wood products in having a permanent supply of raw material. Some pulp men buying their raw material are actually figuring the profits only on the manufacture of the pulp and paper, with no profit on the raw material. It is entirely conceivable that some pulp-and-paper men owning their timberlands would be willing to raise their own raw material without any profit if they were assured of a continuous supply. The business of growing timber can not, therefore, be entirely separated from the business of manufacturing it. Wood-using plants which have their own timber supplies are in a far more advantageous position to manufacture the product than concerns that have to buy their raw material outside. This, of course, is on the assumption that all other conditions are the same.

SUSTAINED YIELD—THE BASIS OF FOREST MANAGEMENT

Continuous forest production is the backbone of forest practice and industrial stability. Without the assurance of a permanent supply of raw material in the region the permanence of the wood-

using industries is not secure. The pulp-and-paper industry in some localities is now learning this lesson through bitter experience, and the same is true of other industries dependent upon wood.

Continuous forest production involves a plan of management for the property, an inventory of the stand by age classes, and a determination of the annual growth and of methods of cutting that will insure regrowth on the cut-over land and continuous yields. This in turn involves employment of technical experts capable of making an intelligent inventory of the forest property, preparing plans for its management, and providing technical supervision of the actual operation. It means the employment in the lumber industry, as in mining and other industries, of men who have had professional training within this field. Only a technical personnel, trained for the work, can apply intensive methods for handling the forest as a crop.

What methods should be applied for the different forest types and under the different forest conditions is very difficult to specify. Under intensive forest management foresters may use different methods of regrowth—for instance, natural reproduction or artificial planting—and yet attain the same results. Again, if an aspen stand is to be managed for the production of aspen pulpwood one method may be applied, whereas if the same type is managed with the aim of converting it into a white pine or spruce stand another method is necessary. There is no universal method, even for the same type of forest, which will invariably produce the best results. Forest practice must vary not only with the forest type but also with the purpose for which the owner may be growing timber.

RELEASE CUTTINGS, THINNINGS, AND UNDERPLANTINGS

To utilize fully the productive capacity of the forest soil for the best growth of the most desirable trees, it will not be enough merely to obtain natural reproduction. The young growth will require tending and care.

When northern hardwoods are cut under the "selective" system, the control of the most desirable species in the second growth is obtained at the time of cutting by favoring the more-desirable species and cutting out the less-valuable ones. The same is true in old stands of Norway and white pine. In both forests the removal of the remaining old stand and after young growth is established and the thinning of the young stand if it is too dense are all that may be required.

However, in clean-cutting old stands of northern hardwoods, where the character of the second growth is determined largely by those species which sprout best either from the stump or from the roots or where the proportion of the less-desirable species is likely to increase, improvement cuttings are needed after 10 or 20 years. Also in dense young stands of jack pine on very poor soils where the growth is stagnating thinnings become essential. (Pl. 4.) Where aspen and paper birch stands are to be converted into more valuable forests underplanting is necessary.

Second-growth hardwoods, that spring up after the clean cutting of the old stand, may have to be gone over at an early age and the

less desirable species cut out or the tops broken off so as to remove their competition with the more desirable species that may be lagging behind. The same is true when a scattering of white pine or white spruce comes up under the shade of aspen that springs up from the roots. To help the white pine and white spruce the aspen overtopping them may have to be removed.

In dense jack-pine stands, in which the growth is slow because of the density of the stand and the poor soil, severe thinnings may have to be made so as to provide more room for the more promising trees. Such thinnings if made at an age of 25 to 30 years may pay for themselves from the products obtained from the thinnings. At present such thinnings would pay only in a few exceptional cases where the local market for firewood is especially good. The demand for such products will undoubtedly increase in the next 10 to 15 years, and thinnings in jack pine, as well as in dense stands of white and Norway pine, will become practicable.

Where jack-pine stands on the better soils are to be converted into white-pine and Norway pine stands and partial cutting of jack pine does not result in a perceptible increase of the better pine, under planting with those species may become necessary. If the remaining stand of jack pine is too dense for successful underplanting, the jack pine may have to be cut out and the entire area replanted. Underplanting is especially desirable where large areas of aspen and paper birch are to be converted into white and Norway pine stands. Where there is already a fair scattering of these species coming up under the shade of the aspen and birch, cutting off the tops of the aspen and birch that overshade the pine may be enough. If there is no natural reproduction of white pine, white spruce, and Norway pine, underplanting with white pine and white spruce is practicable. If the underplanting in fairly open stands of aspen is made when this species is about 25 years old, the aspen may be removed in 5 or 10 years and may pay for the cost of its removal and even the cost of the underplanting.

In cedar and black-spruce swamps, where the stands are too dense, thinnings will greatly improve the growth of the remaining stands, as will also superficial drainage for the removal of the excess water from the swamps.

These measures and others will be applied more and more as forest practice becomes more intensive and as market and other economic conditions justify them. They will be necessary if the full productive capacity of the forest soil is to be utilized and large yields of the desired species obtained.

FOREST PLANTING [6]

WHEN PLANTING IS NECESSARY

In spite of the best efforts there will be failure occasionally to obtain natural reproduction of the desirable species, just as once in a while there are agricultural failures in spite of the best methods of cultivation. In such instances planting may be necessary. If within the forest tract under management bare areas are coming up too slowly to forest growth, planting may prove a profitable and

[6] KITTREDGE, JR., JOSEPH. FOREST PLANTING IN THE LAKE STATES. (In preparation.)

expedient method for obtaining quicker returns. It is doubtful, however, if any wood user, after he has cut clean the forest that supplied him with raw material, will want to plant up the entire area and wait 50 to 100 years for a new supply of raw material.

Planting has its definite place under intensive forest management as an accessory to natural reproduction and the proper handling of the existing forest, or as a means of correcting failures in natural reproduction or of securing stands of the most desirable species. Under such conditions planting may become as desirable as any other method of reproducing the forest.

WHAT TO PLANT

The species which may be planted safely in the northern parts of Minnesota, Wisconsin, and Michigan are white pine, Norway pine, jack pine, and white spruce. On the driest, sandiest soils where only an occasional jack pine or oak is left, Norway or jack pine will give the best results. On the sandy soils of better quality where there is usually some natural growth of aspen, red maple, and hazelnut, Norway and white pine will do well. In the open, Norway is preferable; under a light cover of aspen or brush, white pine. On the heavier soils where the original growth was hemlock, maple, or yellow birch, the best species to plant are white pine and white spruce.

COST OF PLANTING

At the present prevailing prices of labor and material the cost of forest planting in the region ranges from $3 to $15 an acre. Open, sandy land, small, easily handled stock, and reasonably large-scale operations, efficiently handled, will contribute to low costs of planting.

On the Minnesota National Forest 7,400 acres have been planted, at an average cost of $5.10 an acre. On the Michigan National Forest 10,482 acres cost $3.43 an acre. Fourteen thousand acres on the State forests of Michigan, where almost twice the number of trees are planted on each acre as on the national forests, averaged $5.79 an acre. Where underplanting needs to be done, as in open stands of aspen, with only 100 to 200 plants to an acre, the cost need not run more than $2 to $3. These costs are not prohibitive.

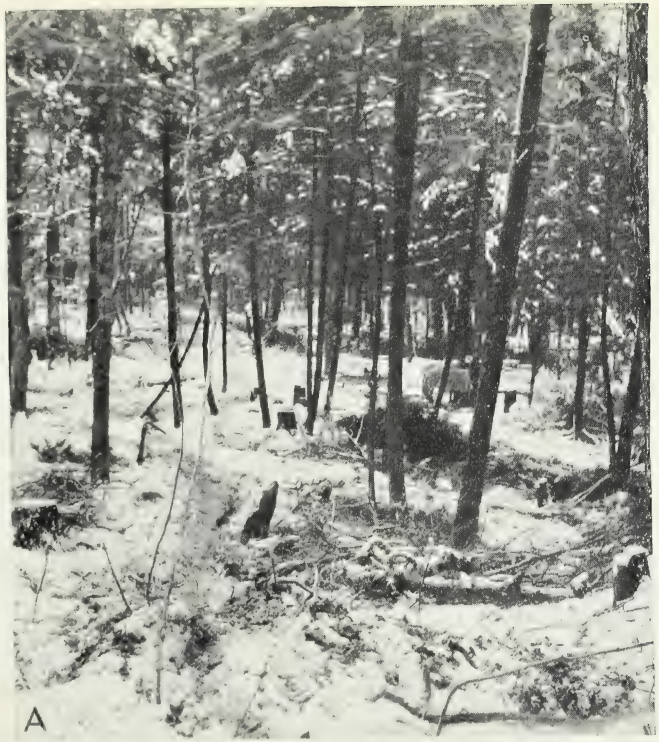
RETURNS FROM PLANTING

It is conservative to predict that planted Norway and white pine will cut 15,000 board feet to the acre in 60 years. Assuming the cost of planting to be $6.50 an acre, a land value of $2 an acre, an annual fire-protection charge of 5 cents an acre, and annual taxes of 10 cents, Norway and white pine at 60 years would have to have stumpage values of only $14 a thousand to earn 5 per cent, or $24 to earn 6 per cent on the investment. With present values of $10 to $15 a thousand, and values in the Northeast for white pine of $15 to $20 a thousand, a future value of $24 is not at all unlikely.

Reforestation by planting in the Lake States is practicable in certain instances even now, particularly with Norway and white pine on the better soils. The costs are not unreasonably high, and the prospective yields are attractive. With better fire protection and modification in the taxation of cut-over land and second growth, planting

THINNING OUT A STAGNATING JACK PINE STAND

The same stand is shown in (A) and (B) before and after thinning. This jack pine on the Cloquet Forest in Minnesota is 27 years old and had grown to 2,200 trees to the acre. Only 700 trees to the acre are left after thinning, but they comprise half of the former volume, and their growth will be greatly accelerated by reason of this operation



SELECTIVE LOGGING AND CLEAR CUTTING

A. Selective logging in northern Wisconsin hardwoods, only one-third of the stand being removed
B. A clear cutting of Norway and white pine after a seed year, with no fire. Natural reproduction is coming in satisfactorily. (F-153296)

promises a fair return of interest on the capital invested. For private owners, however, planting is advisable at present only on the better soils and with species such as white pine, Norway pine, and white spruce.

PROTECTIVE MEASURES AGAINST DISEASES AND INSECTS

BLISTER RUST AND ROTS

In any scheme of intensive forest practice the control of diseases and insects must be taken into account. Aside from the white-pine blister rust and some diseases of aspen and paper birch, the forests of the Lake States are comparatively free of serious disease. The white-pine blister rust, although always a menace, is at present under control in the region, and serious losses of white pine are not likely from this cause if the white-pine forests are protected by the eradication of gooseberry and current bushes from the areas of and adjoining white-pine stands.

Decay in aspen and paper birch, characteristic when the stands reach an age of about 60 years, is quite prevalent, but on account of the abundance of aspen throughout the region and its merchantability before the decay becomes serious, this offers no serious obstacle to growing aspen as a crop. There is no exact knowledge of the manner in which this disease spreads; the method of its control at present is merely to cut and utilize the trees as soon as they become infested. The same holds true of all other species.

INSECTS

The insect depredations, however, are more serious.[7] The spruce bud worm has caused much damage in the Lake States during the past 15 years. The tamarack throughout the region has suffered severely from the attacks of the larch sawfly, which has practically eliminated all large tamarack. Recently, the jack-pine sawfly and the jack-pine tip moth have been abundant, and finally the white pine weevil has done considerable damage in young plantations of white pine.

The ordinary mechanical and chemical methods of insect control usually applicable in orchards and for shade trees are as a rule too expensive to make their use economical in forests. Spraying, for instance, in addition to the cost of insecticides, calls for the use of expensive machinery and equipment. Other methods which might well be used with shade trees, such as banding and tree surgery, are too expensive for use in the forest. Only in rare instances can these methods be economically applied, even to farm woodlands. In the control of forest insects prevention must always be the key, and this presupposes a knowledge of the life history and the methods of attack of the insects.

WHITE PINE WEEVIL

As a means of reducing the damage caused by the pine weevil in a white-pine plantation, the plantation should be set out very dense,

[7] The information regarding forest insects and their control was furnished by S. A. Graham, forest entomologist, attached to the Lake States Forest Experiment Station.

not less than 1,200 trees to the acre. Even closer planting would be preferable. This close planting protects the trees from injury by the white-pine weevil, as the insect does not attack so readily trees growing in dense stands, and the effects of the attacks which do occur are rapidly outgrown by the trees. The extra cost in planting a larger number of trees per acre is justified in the long run, partly by the reduction of the possible loss through the pine weevil and partly by the higher quality of the timber.

SPRUCE BUD WORM

Evidence is strong that the serious outbreaks of the spruce bud worm are due to the presence of many balsam firs in the black-spruce forests. The bud worm attacks first of all balsam fir and, when it finds favorable food, breeds to such an extent that it begins to attack black spruce. Apparently, the only way to prevent epidemic outbreaks of the spruce bud worm is to reduce the proportion of balsam fir in the spruce stands; and this can be done, if at all, only by proper handling of the spruce forests.

JACK-PINE SAWFLY AND TIP MOTH

The appearance of the jack-pine sawfly and the jack-pine tip moth is due to the great increase in quantity of jack pine in this region as the result of fires. The only preventive measure is to limit the amount of jack pine by replacing it with Norway and white pine. If the proportion of jack pine is reduced, the danger of jack-pine sawfly outbreaks will be greatly lessened.

LARCH SAWFLY

Very little is yet known concerning the protection of forests against the larch sawfly. It seems that tamarack in swamps is not safe against attacks by the sawfly. For this reason tamarack is not the most promising species in the swamps. There is a possibility, however, that tamarack grown on the better-drained soils is more resistant to sawfly attack and on such lands may once more become one of the best trees.

GENERAL MEASURES

The most important general principle to bear in mind in the protection of forests against all insect outbreaks is that a forest made up of conifers and hardwoods is always safer from insects than is a pure coniferous forest or a pure hardwood forest. This is particularly true in regions where the natural forests are of a mixed type. Protection against insect attacks, therefore, lies in the improvement of the present forests and coincides closely with the measures advocated for intensive forest practice.

SPECIFIC RECOMMENDATIONS FOR HANDLING THE FORESTS IN THE LAKE-STATES REGION

Owners of forest land, aside from a general knowledge of the conditions essential for keeping their lands productive, must also

know specifically what measures are the most effective to bring about those conditions in the handling of this or that kind of forest. An attempt is therefore made to discuss here such specific measures and their effectiveness. This discussion will, for each type of forest, include both the first essentials for keeping forest land productive and, in addition, the more intensive measures without which the full productivity of the land can not be realized. Such measures, however, as the necessary protective organization, which is alike for all forest types and can be adequately considered only for the region as a whole, will not be treated here.

HARDWOOD–HEMLOCK FORESTS

CUTTING ONLY TREES OF SAW-LOG SIZE

The present practice, not uncommon where there is a market for chemical wood, mine timber, and ties, of cutting trees below saw-log size into these products, is very destructive to the future of the forest land. Even if the logged-off land is protected from fire, much of the young reproduction already on the ground dies when suddenly exposed to light, especially such species as hemlock, beech, and even some maple. What is left of the reproduction, together with the sprouts from the stumps, may eventually make a fairly dense stand of timber, but it will take at least from 100 to 120 years before any saw-log timber can be produced again, and this is likely to be of low grade and of the less desirable species. If there is a market for mine timber, ties, and chemical wood, they should be obtained, as far as possible, from the tops and larger limbs of the felled trees or from second-growth stands in need of thinning.

In hardwoods it is not economical to cut trees below 13 or 14 inches in diameter, because of the high cost of logging and the low grades of lumber obtainable from them. The most economical diameter limit will vary, however, with each individual operation, with the species, and with the market conditions, and should be determined separately for each tract.

The measures essential for keeping hardwood land productive are thus comparatively simple. They involve no essential change in the present logging practice, except that the trees below saw-log size should not be cut and that care should be taken in logging to cause as little damage as practicable to the remaining trees. In the birch–beech–maple forest this would mean leaving trees below 12 or 13 inches in diameter, breast high. Where hemlock is present in the stand it should be cut to as low a size as is marketable for pulpwood, since, if left standing, hemlock is likely to be windthrown or, with the opening up of the forest, to die as the result of exposure to light.

A typical northern hardwood forest is invariably made up of trees of different sizes and ages, from large trees 36 inches and over in diameter to a carpet of seedlings 1 year old, particularly of hard maple. An actual tally of 77 acres of birch–beech–maple forest showed the distribution of trees of different sizes on an average acre as indicated in Table 8.

TABLE 8.—*Average per acre distribution of trees on 77 acres of birch-beech-maple forest*

Diameter breast high in inches	Number of trees per acre	Percentage distribution
2–6	168	64
7–11	36	14
12 and over	59	22
Total	263	100

If only trees of saw-log size are cut, and especially only trees which can be economically logged, the remaining stand will contain 204 trees an acre 2 to 11 inches in diameter, inclusive—or 216 trees between 2 and 13 inches—capable of producing a second cut of saw-log timber equal to the first cut in 50 to 60 years, and subsequent cuts at similar intervals. The higher the diameter limit below which the trees are left uncut, the shorter the period within which a second cut may be expected and the higher the grade of lumber which may be obtained.

In felling the larger trees a certain amount of damage is inevitable. Yet with reasonable precaution much unnecessary breakage can be avoided. In logging a hardwood forest in the Upper Peninsula of Michigan in the summer of 1926 and removing only the larger trees, about five standing trees per acre were broken and had to be cut down, and these were mostly trees between 6 and 7 inches in diameter. If on an average 204 trees an acre below 12 inches in diameter are left in logging, allowing even 10 young trees to be broken down in felling the larger trees, there should still remain 194 trees ranging from 2 to 11 inches in diameter to form the basis of a second cut. If these young trees are to grow up to saw-log size within a short time, they, of course, should not be cut for ties, mine timber, or chemical wood. If all trees below 12 or 14 inches are left, no further provision for seed trees is necessary.

Frequently there occurs within the hardwoods some white pine. It is generally desirable to increase the proportion of white pine in the second-growth hardwood stand because of its higher value and faster growth. Some of the white-pine trees, even above 12 inches in diameter, should therefore be left as a source of seed. It is not advisable, however, to leave very large, old white pine, because the investment in such trees and the hazard of losing them in the course of the next two or three decades are too great.

PARTIAL OR "SELECTIVE" CUTTING IN OLD HARDWOOD STANDS

The amount of old mature hardwood timber left in the Lake States in private ownership is comparatively small. Its area has been estimated at 10,100,000 acres for the entire region, or 3,500,000 acres for Minnesota, 2,100,000 acres for Wisconsin, and 4,500,000 acres for Michigan. The life of the industry based on the old timber is estimated at less than 20 years. In some localities, at the present rate of cutting, the timber will be gone much sooner. Most of this timber is from 100 to 250 years old. The same sizes will never be

grown again, at least by private owners, because of the long time involved. Yet the utilization of this timber is still wasteful. Old white and Norway pine logs are now taken only to 6 inches in diameter at the top. Where hardwoods are being utilized for chemical wood the tops find a market, but in many operations where there is no demand for chemical wood and the timber is utilized solely for lumber large tops remain in the woods.

As this old timber disappears the stumpage value is undoubtedly going to increase. Owners of large saw-log timber in 10 to 15 years from now will, therefore, be able to command prices that justify conservative handling at the present time.

For the owner still having a fairly large supply the old timber may help to bridge the gap until the younger timber reaches maturity, and in this way may enable the operator to carry on his operations indefinitely. Prolonging the life of the old timber by partial cutting, opening up the forest, and allowing the smaller trees to reach larger sizes will prolong the life of the industry based on this old timber. It will mean diminishing the depreciation of the sawmills, for these will be able to run longer as the timber cut is prolonged, thus reducing the overhead charges. The only drawback is that such a forest may still be taxed as a virgin forest in spite of the fact that the amount of merchantable timber has been reduced by one-third.

For all these reasons partial cutting under conditions existing in the Lake States promises the greatest economic advantages and at the same time it is the safest and cheapest way of securing natural reproduction. Where the stand of northern hardwoods—birch, beech, maple—and hemlock runs from 10,000 to 14,000 board feet to the acre and is made up of trees of different diameters from the smallest to the largest, partial or "selective" cutting is advisable from both the economic and the forestry standpoints. How much should be removed in each cutting and at what intervals successive loggings may take place will depend on the character of the forests, the wishes of the owner, and economic considerations.

An actual selective cutting in Wisconsin may be cited as an illustration of the applicability of partial cutting in such stands. The stand is made up principally of birch, beech, maple, hemlock, and some white pine, characteristic of northern Wisconsin. Originally there was a considerable amount of white pine, for which the soil is well adapted. About 27 years ago most of the white pine was cut out, but the forest to-day is just as dense as it was then, although the proportion of white pine is much smaller. The stand on 1,800 acres averages a little over 14,000 board feet to the acre. Trees of all diameters are found.

There are on an average about 225 trees to the acre, ranging from 2 to 36 inches in diameter breast high. Of these, 65 trees are hardwoods and 160 conifers. About 94 per cent of both conifers and hardwoods are of diameters ranging between 2 and 17 inches breast high, and only 6 per cent of all the trees are 18 inches and over in diameter.

Close to 90 acres of this forest was logged during the winter of 1924–25 and a total of 350,000 board feet cut out, or an average of about 4,000 feet to the acre, which is approximately one-third of the volume of the merchantable stand. This roughly coincided with a

diameter limit of about 18 inches. Only the large trees and those that were defective, decrepit, and dead were removed.

At the present rate of growth of 200 board feet per acre per annum on the cut-over land, it is figured that a similar amount may be cut from the same area in about 20 years, and with the improvement resulting from this cutting a larger annual growth may be expected. A larger amount will therefore be available for cutting for several successive 20-year periods.[8] (Pl. 5, A.)

Since the soil was well adapted to white pine and white pine is the fastest growing tree, the purpose in handling this forest was to increase the proportion of white pine. Therefore, no white pines were cut, except that where they occurred in groups some were thinned out. The only other pine logs taken out were from dead or down trees. Besides white pine, the other species favored were Norway pine, basswood, yellow birch, red oak (*Quercus borealis maxima*), and sugar maple. On the other hand, hemlock, beech, paper birch, balsam fir, and ironwood (*Ostrya virginiana*) were taken out regardless of size.

The most striking thing, however, about this selective logging was that the logging costs per thousand board feet were not only no higher but actually lower than if the tract had been cut clean in a typical hardwood-logging operation. The contract of cutting 350,000 board feet was let out to people in a neighboring village for $10 a thousand, which included felling, skidding, disposing of slash, hauling 2½ miles on sleighs to the railroad, and decking by the railroad.

The actual cost of the logging to the contractor was only $7.30 per thousand, distributed as follows:

	Per M board feet
Felling and bucking	$2.00
Skidding and landings	2.25
Roads	.10
Hauling to railroad	2.00
Decking	.25
Labor insurance	.30
Disposal of brush	.40
	7.30

The men made good wages, and the job was well done. The slash along roads was piled and burned. The rest of it was lopped from tops and scattered so that it lay close to the ground.

If the lumber company had done the logging itself, it would have cost about $2.50 more per thousand to cover the costs of loading on the cars, camp, and equipment, construction of railroad, and supervision. Such selective logging, if done as a large railroad job, has been estimated by logging operators to cost about $10.25 for the first 12 years. After grades had been built successive logging costs would be reduced to about $9.50 to $9.75 at the present prevailing prices of labor and material. These low logging costs, due largely to the size of the logs handled, compare favorably with other present logging costs on operations where all the merchantable timber is

[8] WATSON, RUSSELL. NOTES ON NATURAL REGULATION AND GROWTH OF NORTHERN HEMLOCK AND HARDWOOD FORESTS. Jour. of Forestry 23: 936–940.

removed and no slash disposed of. And the forest is left in a better growing condition than before, with assurance of another cut of timber and with practically no additional cost for reforestation.

Such a forest would be able periodically to provide large veneer logs or logs yielding high-grade lumber. An additional advantage of this cutting is that such logging does not mar the æsthetic value of the forest, a very important consideration in this instance, for the operation surrounds a lake fringed with summer homes.

But what is even more important than the preservation of aesthetic values is that this forest has been left in an almost fireproof condition and is almost as safe, or will be in the next three to five years, as any old-hardwood forest. This company has now been convinced of the advantages of selective cutting and about 1,000 acres have since been logged in the same manner.

Another example of selective logging, in the Upper Peninsula of Michigan, near Marquette, may be cited. In a stand of timber which averaged 6,350 board feet net log scale per acre, 35 per cent, or 2,250 board feet, was removed in selective logging. In all, 45,000 board feet was removed from 20 acres, and in addition about 250 cords of chemical wood was cut from the defective portions of the trees, from the tops, and from the small cull trees which were considered not worth retaining in the stand. The stand averaged 190 trees per acre between 3 and 38 inches in diameter. On an average about eight trees were cut to the acre, and the diameter of the trees cut corresponded roughly to a diameter limit of 22 inches breast high.

The logging was done by a contractor at a cost, including felling, hauling, and loading on the cars, of $10.50 per thousand board feet. The cost of cutting, hauling, and loading chemical wood, which was disposed of at a stumpage price of 50 cents a cord, was $4 a cord.

On the entire tract only 89 trees were knocked down by felling, and only 3 of these were 12 inches or over in diameter. The cutting demonstrated that selective logging can be carried on under practical logging conditions without appreciable damage to the trees which are to be left for the next cutting. It has shown further that the cost of the method is not prohibitive; that the cost per thousand board feet compares very favorably with the usual large-scale operation where the forest is clear-cut. Since the tops and the large limbs were cut into chemical wood down to 3 inches, there was no expense for slash disposal.

A most striking result of selective logging in this instance is that, because of the high quality of the product, more than half of the value of the stand was removed and yet only one-third of the volume. The average value of hardwood logs cut in ordinary logging operations during the winter of 1926–27 was about $19 a thousand feet on the cars and in some localities even less. Of these logs cut under selective logging, the maple logs were worth $27.30 a thousand feet, and the birch $39.31. Since there were cut 6,124 feet of birch logs and 39,048 feet of maple, the average value of the logs cut on the 20 acres was $28.93 a thousand feet. Had the entire stand been cut the value of the logs at $19 a thousand feet would have been $120.65 an acre. The value of only 35 per cent of the volume, in logs taken from the largest trees, was about $65 an acre.

An account of the actual use made of the logs cut selectively, as given in Table 9, is of interest.

TABLE 9.—*Actual use of selectively cut logs*

Species	Veneer		Bowl logs		Woodenware	
	Board feet	*Per cent*	*Board feet*	*Per cent*	*Board feet*	*Per cent*
Maple	12,531	32.1	18,991	48.6	7,526	19.3
Birch	3,005	49.1	1,917	31.3	1,202	19.6

The chemical wood, produced from the tops and defective portions of the trees and from smaller defective trees, aggregated about 250 cords and brought in an additional $125, or $6.25 an acre.

The proceeds and the logging costs on the 20 acres, not including charges on the investment or any other carrying charges, were as follows:

Receipts from selective logging

45,000 feet of logs, at $28.93	$1,301.85
Cost of logging, at $10.50	472.50
Receipts from logs after deducting logging cost	829.35
Receipts from 250 cords chemical wood, at 50 cents stumpage	125.00
Total receipts from 20 acres	954.35
Receipts per acre	47.72

Another feature of selective logging was the fireproof condition in which the forest was left. As a result of cutting only trees over 22 inches in diameter and of utilizing the tops down to 3 inches for chemical wood, very little slash was left on the ground. The small quantity that was left will remain moist in the shade and will soon rot. Except for the scattered stumps, there is little to indicate that one-half of the value of the stand has been removed from the 20 acres. The stand has the appearance of a virgin hardwood forest. Since the forest has been left intact, the air will constantly be moister here than it would be if the stand had been cut clean, and the surface soil will remain cooler and damper throughout the critical spring and fall fire seasons, as well as through the entire summer.

Another fact of importance is that the logging was done by a local settler, to whom the winter work was a source of income, affording him the opportunity to develop his farm during the summer and helping him to become a permanent settler.

In another 20 years the 41 trees per acre between 12 and 22 inches in diameter left under selective logging will increase 2 to 4 inches in diameter. This will more than make up for the 2,250 feet removed in the selective logging. In 20 years the growth of the trees left now will bring the stand back to its original volume, and it should be possible to make another selective cut at that time of as high quality timber and to get for it at least a similar return. With selective logging, then, the forest will be continuously productive, bringing in, according to this example, approximately $50 an acre every 20 years, or $2.50 an acre every year, not counting carrying charges.

This selective cutting, although only one year's cut and by no means conclusive, opens up perspectives and possibilities worth considering. Many lumber companies, laying out their logging op-

erations, leave the tracts nearest to the mill and accessible to the means of transportation until they are toward the end of their operations. These tracts may not be cut for another 25 or 30 years. Meanwhile there are taxes, protection, interest on the investment, and other carrying charges to pay. At present the net growth of these old stands is nil, the growth being offset by the natural decay. If these tracts were now cut over selectively, the bulk of the investment could be removed and yet two-thirds of the stand be left in a good growing condition, producing from 125 to 200 board feet per acre per year. In 25 or 30 years, when these tracts would ordinarily be cut, their stands, would have again become fully as heavy as they are to-day, and the likelihood is that the timber would be of better quality.

There is another consideration in that these accessible tracts are surrounded here and there by settlers who are trying to make a living on the land. These settlers would be engaged continuously in the selective logging of these accessible tracts, and their position would thereby be strengthened as permanent settlers and farmers.

At present, there is a double waste. On the one hand, logging at the end of the logging road, miles away, is wasteful, and destructive to the future of the forest. On the other, there is the waste caused by the loss of growth in the old stands accessible to transportation and towns. This double form of waste could be greatly reduced by the adoption of selective logging, as illustrated by the cutting at Marquette.

Selective logging tends to maintain the output of a high-grade product, such as veneer and pin logs. This insures a high revenue and, since the trees of smaller size are left standing, reduces the logging cost. Most important of all, it leaves the forest in good growing condition. It is logging for a continuous supply of high-grade lumber, as against mere volume production.

SLASH DISPOSAL

Where the tops are utilized for chemical wood down to 3 inches, within three or four years the slash ceases to be a fire menace. Even where the tops are left in the woods, they need not be piled and burned, provided precautionary measures are taken to clean up the slash along highways, logging roads, and trails, and the logged-off area is patrolled carefully. In cleaning up the rights of way, trails, and highways, the following procedure is recommended:

1. All slash and other inflammable débris should be burned when logging roads and railway spurs are cleared, the slash being carried to the middle of the cleared strip and burned as clearing progresses. The slash should never be thrown in windrows at the edge of the right of way, as is frequently done. After cutting has begun, all slash along the main logging railroad and spurs should be piled and burned for a distance of 50 to 100 feet on each side of the right of way. This should be done as cutting proceeds, or, if burning at that time is unsafe, the brush should be piled and burned after the first light snow the following fall. Piling is essential if a thorough burn is to be effected.

2. Slash along trails and highways should be disposed of by piling and burning for a distance of from 50 to 100 feet on each side of the road or trail, if possible at the time of logging.

3. Safety zones should also be burned around settlers' homes, close to green timber, etc. The slash in every case should be piled to secure thorough burning of the débris.

4. If the slash is very heavy and covers a wide continuous area, it may be desirable to break up the logged-off land by strips about 50 feet wide on which the slash is piled and burned.

5. Snags and dead trees should be felled, especially birch snags, as they often help to spread fires and make them hard to control. It is the experience of many timber operators that enough sound logs are salvaged to more than pay for felling all snags.

In partial cuttings an attempt should always be made to find a market for the tops of the trees and for the culled logs. In some localities they can be marketed for chemical wood. Such wood is taken to 3 inches at the top and solves well the problem of slash disposal. Occasionally where there is no market for chemical wood some demand for firewood, mine timber, and even ties can be created for the tops. Even if the disposal of the tops for these products merely covers the cost of their removal it is still an advantageous operation for the timber owner, as it reduces the fire risk and leaves the land in a more desirable condition for future growth.

Where the tops are not utilized they should be left flat on the ground, except along the skidways, where they should be piled and burned at the first favorable opportunity. Under a partial system of cutting the fire hazard is reduced, the slash is comparatively light and is left at separated points, the humidity within the forest is high, and herbaceous vegetation under the shade of trees remains green in the fall, when in the open all the grass is already frost-killed and readily inflammable. All these conditions make a forest cut over in such a manner fairly fireproof and the leaving of slash on the ground an efficient method of disposal.

YIELDS AND COSTS

Where the entire stand is cut clean for saw logs, ties, mine timber, and chemical wood, if a dense reproduction is already on the ground and the logged-off area is protected from fire, the land may be expected to produce in 100 years 6,000 and in 120 years 8,000 board feet per acre. If trees of saw-log size only are removed, or only such saw-log trees are cut as can be economically logged, the growth per acre per year after logging may be conservatively estimated at from 100 to 125 board feet, or 6,000 board feet within 50 or 60 years after logging.

What are the elements of cost and the basis for computing the probable returns? Again, without attempting to indicate in absolute figures the profitableness of timber growing in general, the financial considerations involved may be stated. The average stand of hardwoods per acre over large areas is about 6,000 board feet net log scale. If it takes 100 years to produce 6,000 board feet, with no other forest expenditures except fire protection, taxes, and interest on the land, and the timber company is a going concern with sufficient

cut ahead of it, then the annual proceeds of 1 acre must provide for fire protection, taxes, and interest on land value for 100 acres, as is shown in Table 10. Where logging removes all saw-log timber but leaves the smaller trees suitable for ties, mine props, and chemical wood, so that the stand is renewed in 60 years, and 1 acre must pay carrying costs on 60 acres only, it is justifiable to charge some interest for the value of the small timber left. (Table 11.)

These computations are based on the assumption that the stumpage prices within the next 60 or 100 years will remain stationary. As a matter of fact, judging by the rate of increase in the past, stumpage prices will probably double within the next 40 years.

TABLE 10.—*Annual costs and returns from clear cutting in old hardwood stands; 100 acres in 100 years; yield, 6,000 board feet per acre*

Item	Costs	Returns
6,000 board feet cut annually on 1 acre, at $6.50		$39.00
Fire protection on 100 acres at 3 cents per acre	$3.00	
Taxes, at 10 cents per acre	10.00	
Interest on land value of $2 per acre, at 4 per cent	8.00	
Annual cost of carrying 100 acres		21.00
Net return on 100 acres		18.00
Net return per acre		.18

TABLE 11.—*Annual costs and returns from cutting only trees of saw-log size on 100 acres of old hardwoods in 60 years; yield, 6,000 board feet per acre*

Item	Costs	Returns
6,000 board feet cut annually on 1 acre, at $6.50		$39.00
Fire protection on 60 acres, at 3 cents per acre	$1.80	
Taxes and interest on cord wood left	12.00	
Interest on land value of $2 an acre, at 4 per cent	4.80	
Annual cost of carrying 60 acres		18.60
Net return on 60 acres		20.40
Net return per acre		.34

Under selective logging, in which one-third of the volume of the stand is removed, the growth that may be expected after logging will vary from 100 to 200 board feet per acre per year, according to the distribution of tree sizes left and the original volume. If, for instance, the original stand had 12,000 board feet and the proportion of trees between 11 and 18 inches in diameter was fairly large, an annual growth of 200 board feet per acre, after removing 4,000 board feet, is not excessive. If, on the other hand, the original stand had only 6,500 board feet per acre and 2,500 board feet were removed in the first logging, an annual growth of 100 or at the most 125 board feet per acre is about all that may be expected. As a general rule, a forest cut selectively will grow at the rate of from 2 to 2.5 per cent a year. At this rate the timber removed in the first logging is replaced by growth within 20 or 25 years.

In attempting to determine the financial possibilities of such forest practice, the costs, investments, and returns must be con-

sidered. A concrete illustration will help to analyze the financial basis of the calculations involved. It is assumed that a lumber company is in the timber business permanently and is a going concern. It desires to engage in selective logging and remove at each operation about one-third of the original volume, returning to the same land for another cut within about 20 years. The average stand per acre is, say, 9,000 board feet log scale. It removes in the first operation 3,000 board feet, or about one-third of the stand. The present average stumpage price for hardwoods is in the neighborhood of $6.50 per thousand. Since it removes only one-third of the stand, two-thirds of the stumpage is tied up for 20 years. As the total stumpage value per acre is $58.50, that means that $39 is tied up for 20 years and is entitled to earn at least 4 per cent interest.

The returns, under selective logging, per thousand board feet, are much higher than those from ordinary logging, since only the large choice logs are taken. The average price for logs under selective cutting is from 50 to 100 per cent higher than the price for the average run of logs under clean cutting. The stumpage for the large trees cut must therefore be credited with a higher value than the ordinary stumpage. The stumpage of such trees may be placed at a low estimate at $15 a thousand. For this reason, although one-third of the volume of the stand is removed, nearly 77 per cent of the value of the stand is taken out, leaving only about $13.50 per care as an investment, or $270 for 20 acres. As selective logging involves marking of timber and general technical supervision, the cost of such service is included in the calculation. The cost of fire protection, because of the small fire hazard, is low, while the taxes on the other hand are fairly high. The calculations are given in Table 12.

TABLE 12.—*Costs and returns from selective cutting of 3,000 board feet annually out of a hardwood stand of 20 acres yielding 9,000 board feet per acre; 20-year rotation*

Item	Costs	Returns
3,000 board feet cut annually on 1 acre, at $15		$45.00
Fire protection and technical administration on 20 acres, at 5 cents per acre	$1.00	
Taxes, at 50 cents per acre	10.00	
Interest, at 4 per cent on:		
Land value at $2 per acre	1.60	
Timber left ($270)	10.80	
Annual cost of carrying 20 acres		23.40
Net return on 20 acres		21.60
Net return per acre		1.08

NORWAY AND WHITE PINE

CLEAR CUTTING

Clear cutting of Norway and white pine, even with subsequent fire protection of the logged-off land, will seldom result in satisfactory second growth of the same species. When all the trees are cut, if the area is not immediately seeded and no white-pine seedlings are present, the ground is usually soon overrun by hazelnut and other shrubs, especially if the soil is fairly good. This makes subsequent reproduction

of pine difficult. Occasionally clear cutting Norway and white pine, if it occurs during or immediately after a good seed year, or if young seedlings are still present from previous seed years and the logged-off land is thoroughly protected against fire, may result in a good second growth of the original species; but otherwise it will not as a general rule prove satisfactory. Abundant seed years occur in Norway pine forests only once in about 7 years and in white pine every 3 or 4 years, and it is out of the question to carry on logging so intermittently. (Pl. 5, B.)

LEAVING SEED TREES

If Norway-pine and white-pine land is to be kept productive, more than mere protection of the logged-off area is necessary. The least that can be done is to leave two or three to the acre of the smaller and more wind-firm trees for seeding the ground. If the seed trees are of low merchantable value, and if they succeed in reseeding the cut-over land, the stumpage value in them would be less than the cost of planting the land; moreover, these seed trees may still be standing at the time of the second cut.

Leaving seed trees is, however, a very uncertain measure. The trouble is not with the trees failing to produce sufficient seed, but with the fertile soil, which quickly overgrows with shrubs, grasses, and other herbaceous vegetation, thus preventing the seed from finding lodging. If the seed does germinate the seedlings are apt to be smothered by the weeds. There is also the danger of rodents eating up most of the seed.

On sandy soils capable of supporting Norway or white pine, success with seed trees may be more satisfactory, but the usual result on such soils following clear cutting of both of these pines is that even in the presence of a few seed trees of these species jack pine freely takes possession. Instead of Norway or white pine, the second growth may consist largely of jack pine. Leaving seed trees is at best a compromise. (Pl. 6, A.)

CLEAR CUTTING WITH PLANTING

Where clear cutting, with or without seed trees, has failed to result in prompt restocking, planting is the only means by which the original species can be brought back.

PARTIAL CUTTING

The most effective way of handling the old Norway and white pine stands is by partial or "selective" cutting. As practiced on the Minnesota National Forest this method removes only a part of the merchantable stand, leaving at least 10 per cent in volume of the merchantable trees. Leaving 20 or 25 per cent is a still safer procedure. Where there are 500,000 board feet or more per 40 acres, or 12,000 or more board feet per acre, at least 20 per cent of the scale in the form of small merchantable trees should remain uncut for at least 10 or 15 years. After the cut-over area has been restocked to Norway and white pine, the remaining old timber may be

removed. Stands with less than 500,000 board feet to the 40 acres are more of a problem unless very accessible and easily logged, in which case the same method as above could be employed. (Pl. 6, B and C.)

SLASH DISPOSAL

Whether the timber is clear cut or partially cut, slash should be disposed of over the entire area by burning in piles at the time of logging and before skidding. As previously stated, this method has been proved to be successful for this type.

PROBABLE YIELDS AND COSTS

What future crops the land will produce will depend largely upon the manner of cutting the old timber. If the forest is cut clean and no seed is available immediately before or at the time of logging, there may be no second growth of Norway or white pine, and, therefore, no future yields of these species; in their place may be either a scattering stand of jack pine, which in 40 years will yield from 5 to 10 cords per acre, or in the better white pine land a stand of aspen, which in 40 years will also yield on an average about 10 cords per acre. Even under simple forest measures, such as fire protection, leaving a few seed trees, or logging during good seed years, the resulting stand of Norway and white pine may produce 8,000 to 10,000 board feet per acre in 80 years. Under partial cutting, or clear cutting with planting, Norway and white pine may be expected to produce in 80 years, on an average for good and poor soils, about 20,000 board feet, or to grow at the rate of some 250 board feet per acre per year.

The costs involve for the simplest measures only fire protection, in addition to annual taxes and interest on the value of the land. Under forest management there will be, aside from these, either carrying charges on the reserved stumpage, or the cost of planting up the cut-over lands. The latter will involve an expenditure of about $7 per acre.

JACK PINE

PERPETUATING PRESENT STANDS

If the aim is to perpetuate the present jack-pine forests in the Lake States, clear cutting is all that is needed. Precaution should be taken, however, not to make the clear cuttings contiguous over too large an area. For the sake of safety, the clearings should be not larger than 40 aces. Jack-pine reproduction will follow on all save the heaviest soils, but with repeated burning the quality will become poorer. On the poorest sandy soils, where the area has not been denuded by repeated hard burns, second growth may be so thick that early thinnings will be necessary to avoid stagnation and to get the best results.

PARTIAL CUTTING TO INCREASE PROPORTION OF NORWAY PINE AND WHITE PINE

The timber owner, however, unless interested only in pulpwood, will find that growing Norway pine and white pine will prove more profitable in the long run than the growing of jack pine.

While jack pine grows faster than either of the best pines up to 30 or 40 years, after that the yields from Norway and white pine will be greater if the soil is at all suitable for those species.

The area of jack pine is very large and is increasing. With the better fire protection that is coming throughout the Lake States region, jack pine will be relatively abundant in the next 15 to 20 years. On the other hand, the supply of large saw-log material is rapidly decreasing, and the shortage of such material will be felt more and more. It may, therefore, pay the timber owner gradually to convert jack-pine forests on soils suited to Norway and white pine to the better species. Where jack pine, as in the northern part of Minnesota, occurs with white and black spruce, it may pay even to favor the spruces in the future stands.

The best way to do this is by partial cutting the jack pine. If only 50 per cent of the merchantable stand is removed conditions will be more favorable for the growth of white spruce or Norway and white pine than for jack pine. Jack pine springs up most abundantly on areas which have been once burned over, and requires full sunlight for its best development. It suffers even from light shade. For this reason, if jack pine is not cut clean but about half of the merchantable stand left for another 40 years to ripen into saw-log material, the chances are that the second growth will contain less jack pine and a larger proportion of white spruce and the better pines, depending upon the locality and the presence of these species near the area. In this way the jack pine may be gradually converted into a more valuable forest. It is a safe procedure, for, if Norway and white pine or white spruce fail to come up, it will still be possible to obtain reproduction of jack pine when the remaining mature jack pine is cut, if not before.

Leaving jack pine to grow for 80 years to saw-log size will also prove advantageous, as the stumpage price of jack pine saw-log material is only a little lower than that of red and white pine. Aside from other considerations, the thinning of jack pine should stimulate the growth of the remaining trees.

Partially cutting jack pine stands as a means of converting them into a more valuable coniferous forest seems to be especially adapted to the pole-wood stands of jack pine found on the thin outcrop soils in northeastern Minnesota. Those jack pine stands are now in the natural process of conversion into white pine, spruce, or Norway pine forests. These species, however, do not come in in sufficient abundance until the jack pine stands thin out naturally with age. Cutting out the smaller trees for pulpwood will encourage this conversion process. After reproduction of the more valuable coniferous trees has been abundantly and thoroughly established, the mature jack pine trees can be cut clean and the conversion process completed. Where partial cutting is impracticable and yet the object is to convert jack pine into more valuable stands of Norway or even white pine, the planting of these species is the only quick procedure. (Pl. 7, A.)

SLASH DISPOSAL

When jack pine is cut clean to release the reproduction of better species, the slash should be disposed of over the entire area by progressive piling and burning, as in Norway and white pine stands,

except that in inaccessible places, where the slash is light and the danger from campers, tourists, and travelers starting fires is slight, slash may be left scattered and unburned. The sun's heat near the ground will open up enough cones to provide abundant restocking of the land.

Where jack pine is cut partially, the brush should be burned as the logging proceeds.

PROBABLE YIELDS AND COSTS

With no more than mere protection against fire young jack pine stands will almost certainly yield 20 cords per acre within 40 years over wide areas, or half a cord per acre per year. Higher yields can be obtained if the land is fully stocked and the young stands are thinned in time. The first thinning should take place at the age of 10 to 15 years and be followed by repeated thinnings at definite intervals according to the density of the stand and character of the soil. Yields of fully stocked stands as they are found to-day are indicative of what the yields of jack pine may be over wide areas under forest management. Fully stocked stands yield within 40 years on the poor soils 16 cords of pulpwood and practically no saw logs, and on the good soils 35 cords of pulpwood, or 5,500 board feet Scribner decimal C scale and an additional 20 cords of pulpwood. In 50 years the yield of fully stocked stands on the poor soils is 22 cords, or 5,000 board feet and 19 cords of pulpwood; and on the good soils, 43 cords of pulpwood, or 11,500 board feet and 14 cords of pulpwood.

To obtain these higher yields from fully stocked stands, additional costs besides that of protection against fire will be involved, namely, technical supervision of cutting and slash disposal, and timely thinnings. No data are available as to the cost of thinning. The expense of thinning 10 or 15 year old stands of jack pine should not, however exceed $2 or $3 per acre, while thinnings in old stands, even to-day, can in some parts of Minnesota be made to pay for themselves.

ASPEN AND PAPER-BIRCH STANDS

PERPETUATING ASPEN

If the object is to perpetuate aspen, clean cutting with fire protection is all that is needed. The second-growth aspen does not generally depend upon seed but springs up from the roots and, therefore, clean cuttings over large areas are safe. At present, aspen should be cut to as low a diameter as the market will take. Where there is a market only for the larger trees, thinning the larger trees and leaving the smaller ones is also a safe method of cutting.

The returns from aspen stands are comparatively low, and its abundance in the region does not promise large future returns from such a form of forestry. Aspen and birch are only locally in demand at the present time for excelsior, pulpwood, wood turning, box boards, and firewood, and, therefore, their value is low. Most of the aspen stands have not reached merchantable size and are not so located as to be readily marketable. Every timber owner of large areas of aspen and paper birch, unless he is primarily interested in an industry dependent on these woods, must carefully consider the advis-

SELECTIVE LOGGING IN NORWAY AND WHITE PINE IN THE MINNESOTA NATIONAL FOREST

A. Seed trees left have resulted in natural reproduction. (F-153316)
B. A partial cutting that will result in greater growth of the remaining trees and natural reproduction. (F-153310)
C. Here natural reproduction is already coming in following a partial cutting. (F-33735-A)

A. Jack pine 60 years old resulting from clear cutting Norway pine in Wisconsin. Note the red pine in the left foreground. With partial cutting the proportion of this pine in the second growth may increase

B. A partial cutting in a black spruce stand in northern Minnesota. There has been no slash disposal

ability of replacing them by other more promising species such as white or Norway pine or white spruce, for which the soil is well adapted.

CONVERSION OF ASPEN INTO CONIFEROUS STANDS

The conversion of aspen into white and Norway pine or white-spruce forests can be brought about either by underplanting aspen at the rate of 100 to 200 trees per acre or by releasing the young white pine or white spruce if they are already on the ground. Conifers should be planted in mature stands of aspen only where the aspen is to be removed within 10 years after the planting, as otherwise the conifers may not grow or even live. Paper birch, which is usually found in mixture with aspen and other species, should be handled like the aspen.

SLASH DISPOSAL

There is no special problem in slash disposal. Clearing protective strips along roads and leaving the tops so that they will lie flat on the ground are all that is needed. A desirable practice is to cut down the dead birches, since sparks from burning birch snags spread fire over large areas.

Where aspen and birch are cut clean and utilization is very close, as when aspen is used for pulp and paper birch for small turning bolts, the slash may be left unburned provided strips along the logging roads are cleared. Both aspen and paper birch decay very rapidly and within two or three years cease to be a fire menace.

YIELDS AND COSTS

Aspen stands, as they occur over wide areas, yield on an average about 15 cords of merchantable pulpwood in 40 years, or a little better than one-third of a cord per acre per year. In Minnesota a large part of the aspen finds a ready market at an average stumpage price of $1 a cord. In many parts of Michigan and Wisconsin aspen is still only little utilized, and the returns from it are uncertain.

On the better white-pine lands pure aspen with only protection from fire often yields in 40 years 4,000 board feet of saw-log material and 15 cords of pulpwood. In mixed stands of white pine and aspen the yields may vary from that of pure aspen stands to that of pure white pine. Aspen reproduction may be secured at the mere cost of fire protection in addition to the annual taxes and interest on the value of the land. It is doubtful whether more intensive forest practice would increase the yields above those in pure aspen stands on the better soils, unless the aspen stands were to be converted into white-pine or white-spruce stands.

Conversion of the aspen stands, either by underplanting with conifers or by cutting out the aspen to release reproduction of conifers already on the ground, may be effected at a cost of about $2 or $3 an acre. The yields found to-day in small well-stocked stands on land originally in white pine are indicative of the yields that may be obtained under intensive forest management of aspen stands. These yields range from 15 to 40 cords, or from 2,000 to 8,000 board feet, an acre in 40 to 45 years.

SWAMP FORESTS

Because swamp forests as a rule contain a large proportion of trees that are unmerchantable even for pulpwood, present-day logging does not amount to real clear cutting. Yet the small unmerchantable trees left on the ground are usually spindling, easily overthrown by the wind, and generally a total loss. Such cutting results in great waste, especially in pure stands of black spruce. Nevertheless, even such cutting, unless it is followed by very bad fires, does not prevent the logged-off land from coming back to more or less the same species. Since the swamp forests, especially in undrained swamps, are of slow growth and the stands are light, under crude forestry no other method of cutting may be economically justifiable. (Pl. 7, B.)

CUTTING IN BLACK SPRUCE

Cutting in spruce forests may be partial or clear, depending upon the condition of the stand and the natural reproduction in it. Where the stand is dense and is made up of trees of different sizes, the removal of not more than 50 per cent, or preferably less, of the merchantable timber may be desirable. The denser the cover that is left after cutting, the fewer are the chances for wind throw. Where the stand, however, is made up of merchantable trees of more or less the same size and the ground is stocked with fair reproduction, the removal of all merchantable trees is justified both economically and silviculturally.

Black spruce is very susceptible to attacks by bud worm, and large areas have been denuded in recent years by that insect. Although the bud-worm epidemic has now subsided, there is no assurance that it will not occur again. Therefore, leaving mature black-spruce forests uncut is assuming the risk of losing the merchantable stand left on the ground. Evidence points to the fact that the recent outbreaks of the bud-worm infestation have resulted from the increased proportion of balsam fir in certain localities resulting from clear cutting black spruce. Selective cutting should tend to decrease the proportion of balsam fir and thus possibly reduce the danger of another bud-worm outbreak.

CLEAR CUTTING IN STRIPS

A method of cutting that results in good reproduction, offers many conveniences in logging and utilization, and avoids the necessity of marking the timber, is cutting clean in strips from 150 to 200 feet in width, leaving alternate strips from 150 to 200 feet untouched. The timber in such clean cuttings is thrown to the center of the strip, and the tops are left in windrows, while the sides of the strips are left clear for skidding. The abundance of seed from trees on both sides of the strips provides one of the essentials for natural reproduction of the spruce and commends the method. The alternate strips of forest left uncut are removed when the young growth on the cut-over strips reaches the seeding stage and is capable of reseeding the adjoining cut-over strips.

PARTIAL CUTTING IN WHITE-CEDAR STANDS AND OTHER MIXED SWAMP FORESTS

When white cedar grows mixed with spruce it should be handled in the same way as black spruce. No cedar trees that would not make 5-inch by 20-foot poles should be cut. Thinning out of cedar stands would benefit the remaining stand to a large degree, much more than in spruce. For this reason, partial cutting of only the largest trees is desirable. Where there is not enough big cedar to warrant taking it out without cutting the small cedar, the forest should not be cut.

The same methods that apply to white cedar mixed with spruce are also applicable to other mixed swamp forests.

CUTTING OF TAMARACK

Most of the merchantable tamarack in the Lake States is dead and offers no problem in management. All merchantable dead trees should be marketed as soon as possible. Many of them, in spite of the fact that they have now been dead for many years, are still sound and merchantable for ties, pulpwood, and firewood. There is a large quantity of young tamarack coming up in the swamp forests. The tamarack is the fastest growing tree of the northern swamps. No living tamarack trees, therefore, should be cut at present except where thinning is necessary to benefit the growth of the remaining stand.

At best, however, swamp forests, except on the better-drained lands, do not offer large profits to the private timber owner unless the ground and soil conditions are improved by superficial drainage. It is doubtful if the region is now ready for such an intensive form of forestry as is practiced in Finland, Norway, Sweden, and northern European Russia. Experience, in those countries, however, shows that such investment in the removal of excess water from swamps is a paying proposition in the increased timber growth that results from it.

SLASH DISPOSAL

In cedar and spruce swamps, whether cut heavily or not, the slash may be left flat on the ground unburned, provided that it is removed by burning along railroads, logging roads, trails, etc., and that wherever practicable a safety zone is burned around the swamp, between the dry highland and the swamp. Where spruce in swamps is cut clear in strips, the slash should be piled in windrows in the cleared strips. These may be left unburned if a fire line is established around the swamp.

PROBABLE YIELDS AND COSTS

Taking good and bad spruce swamp forests as they come, the land after logging can not be expected to produce naturally more than about 12 cords in 80 years, or less than one-sixth of a cord per acre per year. No other type of forest, however, responds more generously to forest management than swamp forests. Improved growth in swamp forests can not be obtained without soil improvements, or removal of excess water, and can not be accomplished for less than from $3 to $5 per acre. With such improvements, the yield of spruce in 80 years may be 7,000 board feet of saw-log material and 20 cords of pulpwood per acre.

SUMMARY OF RECOMMENDATIONS FOR HANDLING FOREST LANDS

HARDWOOD–HEMLOCK

	First essential reforestation measures	*Forest management*
Fire protection.	Complete fire protection. State-wide protection supplemented by protection of individual tracts.	Complete fire protection. State-wide protection supplemented by special protection of individual tracts.
Slash disposal.	No slash disposal except along highways, logging roads, trails, etc. Heavy slashings over large continuous areas to be broken up by fire strips about 50 feet wide. On these strips the slash should be burned in piles.	No slash disposal except for ordinary precautions of keeping highways and logging roads clear of debris, and within the forest leaving the tops flat on the ground.
Methods of cutting	No change in present logging practice, i. e., cutting for saw logs. Preferably cutting should be confined only to trees that can be economically logged, i. e., to a diameter limit of 14 inches, using tops and large limbs for ties, mine timbers, or chemical wood. Care in logging to guard, as far as practicable, against injuring unmerchantable young trees left standing.	Selective logging. Leave about two-thirds of present merchantable stand, but remove from 50 to 75 per cent of its value by cutting only the largest trees. In second growth, release cuttings and thinnings may be justified to increase proportion of desirable species. Occasional introduction of such species as white pine or other conifers by planting may be desirable.
Yield	After clear cutting, 6,000 board feet in 100 years, or 8,000 board feet in 120 years. If only saw-log timber is cut, 6,000 board feet in 50 or 60 years after logging.	Annual growth of 100 to 200 board feet per acre per year, according to distribution of tree sizes left and the original volume. Growth at the rate of from 2 to 2½ per cent per acre.
Costs	Expense of fire protection at 3 cents per acre, in addition to annual taxes and interest on the investment in land.	In addition to expense for fire protection, annual taxes, and interest on land, there are carrying charges on the capital tied up in stumpage left on the ground, and technical supervision for marking timber.

NORWAY AND WHITE PINE

	First essential reforestation measures	*Forest management*
Fire protection.	Complete fire protection. State-wide protection supplemented by protection of individual tracts.	Complete fire protection. State-wide protection supplemented by protection of individual tracts.
Slash disposal.	Slash should be disposed of over entire area by progressive burning in piles at the time of logging and before skidding.	Slash should be disposed of over entire area by progressive burning in piles at the time of logging and before skidding.
Methods of cutting.	Avoid clear cutting of all merchantable timber, unless there is abundant reproduction on the ground or cutting is done during or prior to good seed year. Leave at least two or three small wind-firm trees of merchantable size on each acre in addition to all below merchantable size. Safer to leave at least 10 per cent of merchantable volume of stand.	Partial cutting, leaving about 25 per cent of merchantable stand, in addition to all trees of smaller size. Clear cutting may be practiced, provided the logged-off land is replanted within three years after logging, before it is overrun by shrubs and grasses.
Yield	Yield may vary greatly. There may be no yield of second-growth Norway or white pine; instead, scattering stand of jack pine, yielding in 40 years from 5 to 10 cords per acre, or on the better white pine land, aspen, yielding in 40 years 10 cords. Or the land may produce in 80 years from 8,000 to 10,000 board feet per acre of Norway and white pine.	About 20,000 board feet per acre in about 80 years for both Norway and white pine. Growth at the rate of 250 board feet per acre per year.
Costs	Only expense is for fire protection, in addition to annual taxes and interest on the value of the land. Cost of slash disposal chargeable to logging and not to timber growing.	In addition to usual cost for fire protection, taxes, and interest on land, there are carrying charges on portion of stumpage left on the ground, or cost of planting up cut-over land, at about $7 per acre.

JACK PINE

	First essential reforestation measures	*Forest management*
Fire protection.	Complete fire protection to growing stands. State-wide protection supplemented by protection of individual tracts.	Complete fire protection to growing stands. State-wide protection supplemented by protection of individual tracts.
Slash disposal.	As a general rule, slash to be disposed of progressively over entire area as cutting proceeds and before skidding. In inaccessible places, comparatively free from fire danger, slash may be left on the ground unburned.	As a general rule, slash to be disposed of progressively over entire area as cutting proceeds and before skidding.
Methods of cutting.	Clear or partial cutting, just as market conditions may dictate, except on the thin outcrop soils in northern Minnesota, where partial cutting should be preferred.	To perpetuate jack pine, clean or partial cutting as market conditions may demand. To convert jack pine into other pine stands, partial cutting at first and removal of stand when reproduction of valuable species is established, or clear cutting jack pine with subsequent planting.
Yield	About 20 cords an acre average in 40 years, including all kinds of jack-pine land, good, bad, and indifferent.	Pure jack pine stands in 40 years, from 16 cords an acre and practically no saw logs on poor soils to 35 cords, or 5,500 board feet plus 20 cords of pulpwood on the better soils. In mixture with Norway or white pine, yield varies from that of pure jack pine to that of pure Norway or white pine.
Costs	No other expense except fire protection, annual taxes, and interest on land. Slash disposal chargeable to logging operation and not timber growing.	Besides fire protection, taxes, and interest on land, there is additional cost of obtaining fully stocked stands or thinning overstocked stands at from $2 to $3 per acre, and carrying charges on portion of jack-pine stumpage left on the ground, or planting costs.

ASPEN AND BIRCH

	First essential reforestation measures	*Forest management*
Fire protection.	Complete fire protection. State-wide protection supplemented by special protection of individual tracts.	Complete fire protection. State-wide protection supplemented by special protection of individual tracts.
Slash disposal.	No slash disposal, except on safety strips along logging roads, highways, etc.	No slash disposal, except on safety strips along logging roads, highways, etc.
Methods of cutting.	No change in present method of cutting. Clean cutting or partial cutting as market conditions justify.	To perpetuate aspen, clean or partial cutting as market conditions may demand. To convert aspen stands to coniferous stands, complete or partial removal of aspen cover where natural reproduction of white pine or white spruce is on the ground. If no natural reproduction is present, underplanting aspen with conifers at the rate of 100 to 200 plants per acre and removal of aspen cover about 10 years after planting.
Yield	On good white-pine lands, pure aspen produces in 40 years about 15 cords of pulpwood.	In pure aspen stands, in 40–45 years, 15 to 40 cords, or in board measure 2,000 to 8,000 feet.
Costs	Expense of fire protection at 3 cents an acre, in addition to annual taxes and interest on investment in land.	To perpetuate aspen, no additional expenses beyond ordinary fire protection, taxes, and interest on land. To convert aspen into coniferous stands, cuttings to liberate natural reproduction of conifers or underplanting with conifers, at a cost of $2 to $3 per acre, and technical supervision.

SWAMP FORESTS

	First essential reforestation measures	*Forest management*
Fire protection.	State-wide fire protection without need of supplemental protection by owner.	State-wide fire protection without need of supplemental protection by owner.
Slash disposal.	No slash disposal except along railroads, logging roads, etc.	No slash disposal, except along railroads, logging roads, etc.
Methods of cutting.	No change in present logging practice	Partial cutting, removing not over 50 per cent of merchantable stand. In dense black-spruce stands of different sizes, partial cutting; in spruce stands of uniform size with fair reproduction, clear cutting, or clear cutting in alternating strips 150 to 200 feet in width. Clear cutting with subsequent planting not recommended, unless swamps superficially drained. Drainage of forested swamps to improve growth may be economically justifiable in near future.
Yield	About 12 cords of spruce pulpwood per acre within 80 years.	Spruce in 80 years, 7,000 board feet of saw-log material and in addition 20 cords of pulpwood per acre.
Costs	No expense beyond usual annual taxes and interest on land.	For partial cutting, in addition to taxes and interest on land, carrying charges on portion of stumpage left on the ground; and under intensive forest management, cost of improving soil conditions in swamp.

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